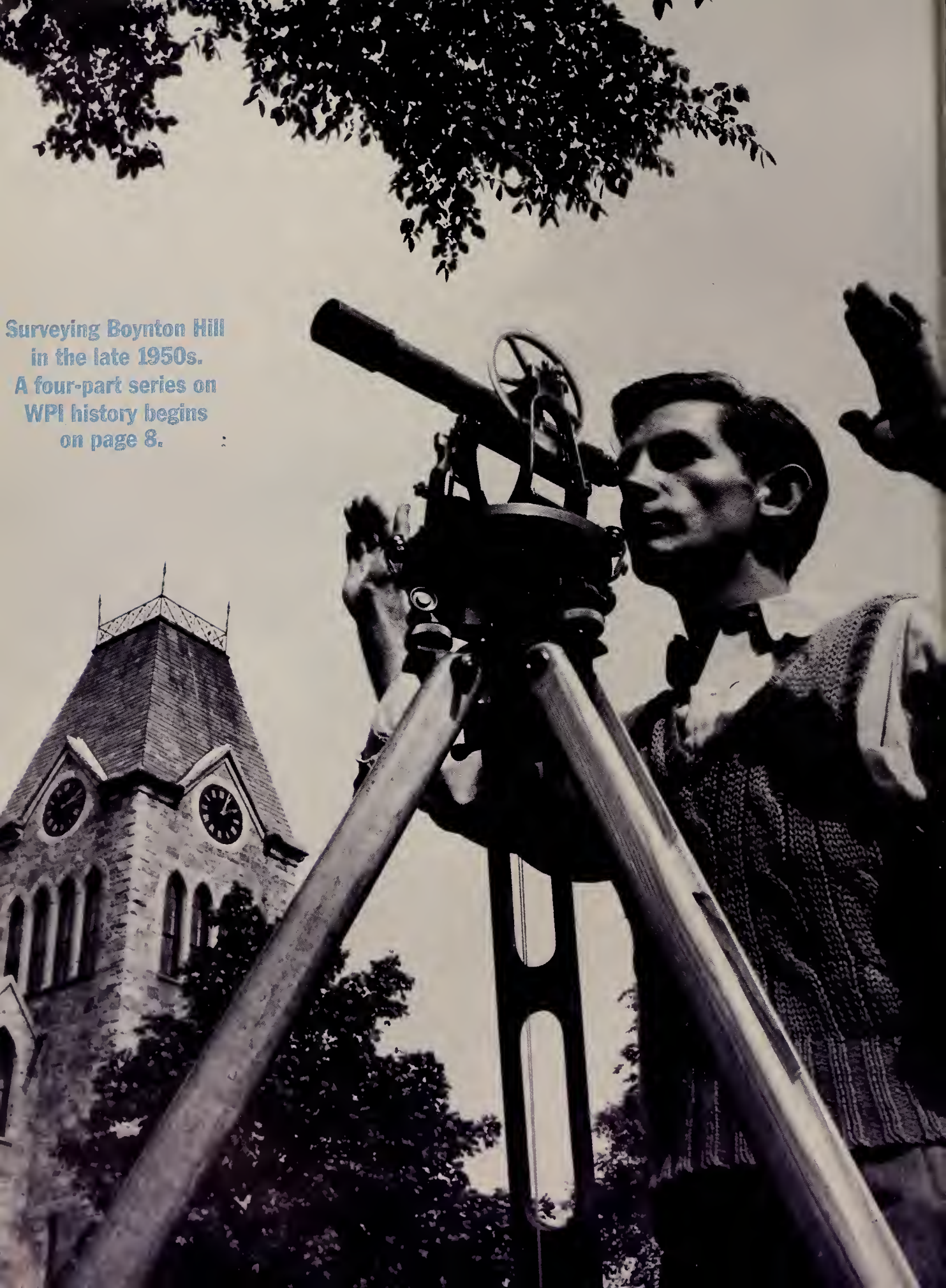
WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

WINTER 1990

A New Lab for a New Science

Gearing up for Europe 1992



Surveying Boynton Hill in the late 1950s. A four-part series on WPI history begins on page 8.

WPI JOURNAL

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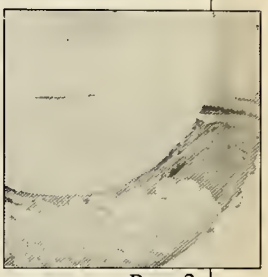

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Photo by Marvin Richmond

Training for a Bold New Industry

In a new laboratory WPI students will learn cutting-edge skills in biotechnology. In the process, WPI will take a major step forward in science education.

By Michael Dorsey

Over the past decade, biotechnology has been transformed from an emerging discipline largely confined to the laboratory to a rapidly growing industry. Today, across the country and around the world, hundreds of companies are harnessing the microscopic manufacturing capabilities within microorganisms, plants and animal cells to churn out a wide range of products—from drugs to food additives to pesticides.

But the transition from laboratory to production plant has not always been a smooth one. Like all chemical processes, the living systems that biotechnology firms seek to exploit can change, sometimes dramatically, as they make the transition from laboratory size to commercial scale. Some organisms that thrive in a bench-top fermentor won't grow at all, or will stop making their product, when cultured at the industrial scale. Getting nutrients and oxygen to cells is difficult in big reactors. And, the heat generated by a large colony of cells can bring a biological process to a grinding halt.

Taken together, these challenges can greatly complicate attempts to culture living cells on a large scale and separate their products from the complex soup in which they grow. In fact, the twin hurdles of enlarging biological processes, called "scale-up," and recovering their products, something scientists refer to as "downstream processing," are two of the most significant problems faced by biotechnology firms.

Later this year WPI will complete work on a new bioprocess technology laboratory on the fourth floor of Salisbury Laboratories. With this facility WPI will become one of a handful of American colleges and universities capable of teaching students these valuable, state-of-the-art skills—skills that are in great demand in the biotechnology industry.

"There is nothing else quite like this laboratory in the U.S.," notes Joseph C. Bagshaw, head of the Department of Biology and Biotechnology. "While there are other similarly equipped facilities at American universities, most are set up primarily for research. The main function of our laboratory will be the education of undergraduates, giving them hands-on experience in some of these vital techniques."

The decision to develop this unique facility is a reflection of the college's distinctive, laboratory-intensive approach to teaching biology and biotechnology, Bagshaw adds.

"The undergraduate program here is research-oriented," he says. "Virtually every course we teach includes laboratory work. Our students also get involved in ongoing research as integral members of research teams. I don't know of any other undergraduate program that offers the laboratory experience we do. We believe this is the best way to prepare students to be professional scientists."

In addition to serving as an educational facility, the 1,600-square-foot laboratory, to be located in what had been the last unrenovated space in the century-old laboratory building, will open new avenues to research in biotechnology (see accompanying stories). Currently, five of the eight faculty members in the department devote the bulk of their research to biotechnology. In addition, three faculty members in the Department of Chemical Engineering do work in the areas of biotechnology and biochemical engineering. All will likely use the new laboratory for at least part of their research.

The seed for the new laboratory was planted four years ago, according to Pamela J. Weathers, assistant professor of biology and biotechnology. With the department already tight on laboratory space, Weathers launched a new course in downstream processing.

The course, the first of its kind in the nation, was made possible by a grant from Bay State Skills Corporation—a quasi-state agency—and through support from a group of local biotechnology companies. It was a great success, Weathers says, but it left her with the conviction that WPI would need a modern teaching laboratory if it was to train its students

JANET WOODCOCK

Education is the primary mission of the new bioprocess technology laboratory. Here Judith Miller (left) teaches students how to use a bench-top fermentor.

in the latest biotechnology techniques.

"We realized that we were not capable of giving students the best possible experience," she says. "We were limited in space, equipment and time. We decided, 'if we're going to have a new space, let's do it right. Let's create a laboratory where students can get a realistic idea of what it's going to be like when they go into industry.' "

Weathers says she and other members of the department felt it was crucial that the new laboratory be outfitted with cutting-edge technology. State-of-the-art equipment gives students the opportunity to train on the same apparatus they will find in industry, she says, and forces faculty members to stay current.

Once the decision was made to establish the new lab, the next step was finding a way to fund it. "State-of-the-art equipment is expensive," Weathers notes. "A modern centrifuge can run from $40,000 to more than $60,000. A computer-controlled fermentor can easily cost $80,000. So, we sat down and thought about how the lab might pay for itself. One option was making the facilities available to local biotechnology firms to serve as a test bed where they could try out a new process before committing to commercial development."

Says Bagshaw, "The new laboratory will enable processes to be scaled up from the bench-top level to 50 liters, which is a major step. Biotechnology companies rarely maintain facilities in this volume range, even though it's an excellent way to test a process at an intermediate stage between the lab and the production plant."

Young companies generally can't afford to build pilot facilities, Weathers says. "If they want to get a process up and answer questions in advance, they can use our facility for a few weeks or a few months. With their questions answered, they can go into production more rapidly and more confidently."

Bagshaw says the laboratory may well be made available to companies on a contract basis to test processes or to grow large batches of cells needed for certain types of industrial applications. The laboratory could also be an ideal setting for short courses and workshops aimed at regional biotechnology firms, he says.

In addition to creating a source of income, involving industry in the laboratory should also make it easier to obtain new equipment for the facility, Weathers notes. "Having companies designing processes with our equipment will be attractive to equipment vendors. We already have companies beating our doors down trying to attract us to their technology."

Initial support for the laboratory has come from several sources. A $95,000 equipment grant, which must be matched by donations from equipment manufacturers, was received from the National Science Foundation. The W.M. Keck Foundation has provided $250,000. And, a $325,000 challenge grant from The Kresge Foundation will ultimately provide money for renovations, equipment and maintenance (see sidebar).

The design for the new facility was developed in conjunction with Peter Brown, founder of Bioprocess Engineering in Worcester. Brown, whose specialty is downstream processing, has developed processes for such biotechnology companies as Integrated Genetics and Genzyme. He will continue to work as a consultant to the department to help get the lab running smoothly.

As much as possible, the lab will be arranged like an actual industrial process facility, Weathers says. Separate rooms will be set aside for culturing cells, running fermentations, preparing solutions and washing glassware. The products of processes run in the lab will be purified in a large, walk-in cold room and studied with a wide variety of analytical equipment. Adjacent to the specialized research areas will be work spaces and equipment dedicated to education.

Among the highly specialized pieces of equipment the lab will house are a 50-liter, computer-controlled reactor for running fermentations; a 14-liter fermentor; equipment for breaking cells open and releasing their contents; a high-performance centrifuge; equipment for separating proteins using gravity, electrical fields and selective adsorption; and equipment—such as high-pressure liquid chromatography, gas chromatography and electrophoresis—for analyzing the products of biochemical processes.

The lab will be the setting for a trio of courses at the undergraduate and graduate levels that cover the basic techniques associated with growing cells and ex-

tracting their products. In the first, a course in fermentation, students learn how to design processes and evaluate them—first in a test tube, then in a flask, and finally in a one-liter fermentor.

"We want our students to think about how they might make use of microbial biochemical processes on a large scale to earn some money," notes Judith Miller, associate professor of biology and biotechnology, who has been teaching the fermentation course for several years. "We are generally interested in metabolic processes that begin in the laboratory, but which must ultimately be run on a scale of 1,000 liters or greater to be commercial."

The next step in the sequence is Weathers' downstream processing course, in which students learn how to design a downstream processing scheme that not only recovers most of the product, but does so as economically as possible.

"More than half of the cost of a biochemical product is tied to fermentation and downstream processing," Weathers notes. "To begin with, the cost of equipment is high. And, since many products cannot be produced in very high concentrations, it can be very difficult and time-consuming to separate and purify them."

The final element of the trilogy is a course still in the planning stages that will teach students how to take a process and enlarge it to a pilot scale.

"To accomplish this," Miller says, "students will have to scale up both the fermentation and the downstream processing ends of a biochemical process to the 50-liter scale. They'll also have to deal with the integration of these two key elements of biotechnology. Very often one of the main considerations in the design of a fermentation process is how easy it will be to separate the product. Ideally, you would first design the separation scheme, and then come up with a fermentation to feed into it."

Central to the course, which may be taught for the first time in spring 1991, will be an actual biochemical process that students will shepherd from bench-top scale to pilot scale. The process is currently being designed by Miller, Weathers, William Clark, assistant professor of chemical engineering, and David DiBiasio, associate professor of chemical engineering. DiBiasio, whose research focuses on how cells behave when grown in bioreactors such as the one that will be used in the scale-up course, says he may get undergraduate chemical engineering majors involved in helping to design and analyze the process.

Miller says support for the course is being sought from Bay State Skills Corporation. She has asked the agency to fund two rounds of the course, one for students on campus and one aimed at practicing professionals from regional biotechnology firms. Input from both groups will help further refine and shape the course, she says.

"The three-course sequence will give WPI a significant competitive edge," Miller says. "It's rare to find fermentation taught as an undergraduate course. The downstream processing course is still unique and the scale-up course will have few competitors. No other college can boast this combination."

"We're sitting on enormous potential," notes Ted Crusberg, associate professor of biology and biotechnology. "We've got the ability to turn this facility into a teaching center for bioprocessing. We may find ourselves attracting many undergraduate and graduate students from other colleges that don't have a laboratory of this sophistication."

Students who take advantage of the new laboratory and its educational opportunities, he says, will leave WPI with more than a solid grounding in one of the most exciting and fastest growing disciplines in science. They will also have a leg up on most of the students with whom they will compete for jobs or slots at graduate schools.

"Our students will receive the same training that most students can only get at the graduate level," Crusberg notes. "They will be a good two years ahead of other undergraduates."

Adds Miller, "I know our graduates are very marketable as it is, just with the level of experience they get in our current courses and labs. With these new facilities and courses, industry is just going to gobble these guys up."

Kresge Foundation Challenge Aimed at Keeping New Lab Up-to-Date

Establishing a new teaching laboratory in science can be a challenging and expensive undertaking. Individual pieces of state-of-the-art equipment in a field like biotechnology can run into tens of thousands of dollars. When the cost of equipment for WPI's new bioprocess technology laboratory is added to the dollars needed for renovations, the final price tag will total more than $650,000.

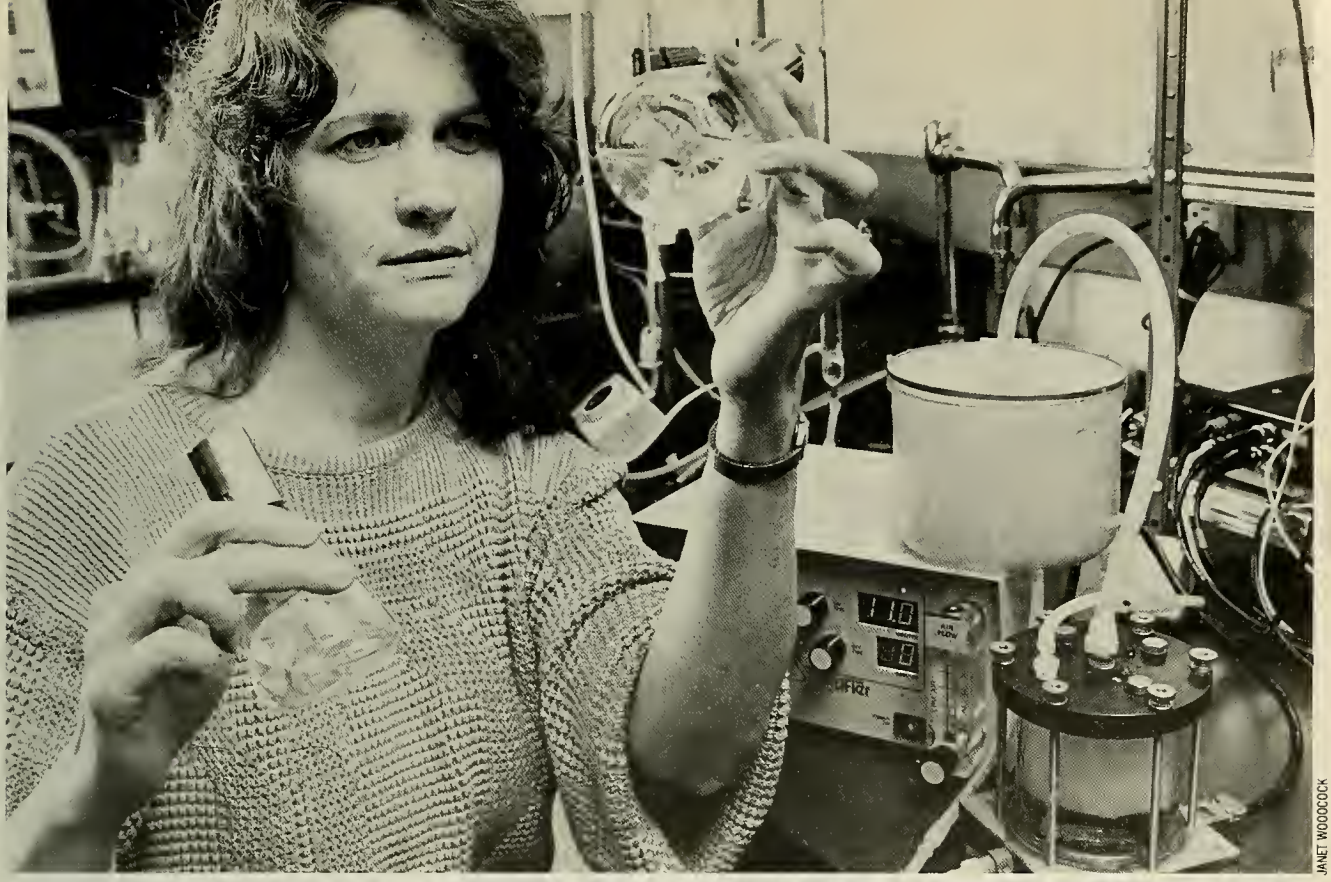
Yet even after construction is complete, the equipment is installed and the new facility is officially open for business, the job of launching the new laboratory will not be finished. New developments in science and technology are occurring at an unprecedented pace. Unless a science laboratory is constantly maintained and upgraded, it can easily become out-of-date.

Keeping laboratories current is a job neglected by too many American colleges and universities, according to several recent studies that have found that less than one-fifth of the equipment in science laboratories at U.S. colleges and universities is state-of-the-art. It is also a vital need rarely considered by donors to colleges like WPI.

To help address both problems—upgrading laboratories and educating donors—The Kresge Foundation last year launched the Science Initiative Program, through which it is challenging colleges and universities to create endowed funds dedicated to the ongoing maintenance of their instructional science laboratories.

Becoming one of the first recipients of funds from this new program, WPI was awarded a $325,000 challenge grant from the foundation in the fall of 1989. The grant, the second challenge grant WPI has received from Kresge during the *Campaign for Excellence* (the first helped build the new George F. Fuller Laboratories), will help pay for necessary renovations and new equipment for the laboratory. To receive the grant, however, WPI must raise, by May 1991, an additional $1.3 million to be placed in a permanent endowment fund to sustain and continually improve this state-of-the-art facility.

"The 'half-life' of equipment in this field is not long," notes Joseph Bagshaw, head of the Biology and Biotechnology Department. "An endowed maintenance fund will ensure that we can continue to offer our students the most up-to-date education for years to come."



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Pamela Weathers is developing a way of extracting artemisinin, a powerful treatment for malaria, from the sweet wormwood plant. The plant tissue is cultured in a sophisticated growth system (seen at right).

A New Twist on an Ancient Remedy

For centuries, people around the world have used chemicals produced by plants to treat a wide variety of ailments. In time many of these herbal remedies, such as acetylsalicylic acid (aspirin) and digitalis (used in treating heart disease), have been exploited and turned into commercially produced drugs. A number of other chemicals naturally manufactured in the cells of plants are used as fragrances for cosmetics and as flavoring agents for foods. The marketing of these "secondary products" (so called because they are not necessary for the basic survival of the plant) is now a multibillion-dollar-a-year industry in the United States.

Currently, according to Pamela Weathers, assistant professor of biology and biotechnology, the only way to recover secondary products is to harvest the plants and then chemically treat the roots or stems to extract the chemicals, an inefficient and wasteful process. Weathers and Professor Ronald D. Cheetham are developing a way of recovering the products without harming the plants.

"Plants grow very slowly, so their biomass is very valuable," she notes. "If you have to kill them while they're in a productive state, that's very wasteful. Our goal is to turn plants into continuously productive little factories. The question is, can we get enough of the product out to make it economically feasible?"

To answer that question, Weathers is making use of a growth system known as the Mistifier™. The system was developed by Weathers and Kenneth Giles, former head of WPI's Biology and Biotechnology Department and now head of the Horticulture Department at the University of Saskatchewan in Canada. It will soon be marketed by the Manostat Corporation of New York. The Mystifier™ uses ultrasonic energy to create a fine mist that can uniformly carry moisture, nutrients and hormones to plant tissue growing in a clear plastic chamber. The system provides unprecedented control over the growth of plants and plant tissue cultures.

One subject of Weathers' research is a species of *Artemisia* known as sweet wormwood. Chinese herbalists have long known that artemisinin, a chemical produced by the plant, is the most effective known treatment for malaria, the world's third most deadly disease. Since the parasite that causes malaria can become immune to commonly used drugs, new treatments will be important in the fight against this largely Third World killer.

In her laboratory, Weathers, along with students Stephen J. Kovacs '90 and Gail L. Auger '90, first cultures shoot tissue from *Artemisia*. The shoots are then infected with a bacterium that carries a piece of DNA that, once inserted into the DNA of the plant cells, will cause roots to grow from the infected sites. The roots are covered with a thick network of fine root hairs, which greatly increase their surface area.

Once the roots are fully developed, Weathers changes the nutrient balance and environment to induce the roots to become leaky and release the artemisinin into the growth medium, where it can be easily retrieved without any significant loss of the plant tissue. The research is still in its early stages, Weathers says. Should the technique prove effective, she will likely use the facilities of the bioprocess technology laboratory to purify the chemical products. She is also working on designs for a larger version of the Mystifier™, one that may well employ automation to tend the plants. Such a system could be used to grow her biological "factories" on a commercial scale.

A Fungus That Eats Heavy Metals

In 1928 Alexander Fleming discovered that the *Penicillium* mold produces a substance capable of killing disease-causing bacteria. Now, more than 60 years later, a relative of the mold Fleming cultured in his laboratory may play an important role in the fight against hazardous waste.

Ted Crusberg, associate professor of biology and biotechnology, has discovered that a variety of the *Penicillium* fungus, if properly grown and treated, can latch onto copper, lead and other toxic heavy metals, effectively removing them from wastewaters.

Grown in a clear, continuously mixed growth medium, the mycelia (plant-like filaments) of the fungus form themselves into small white spheres. Crusberg harvests the spheres and treats them with ethanol and sodium bicarbonate to remove all living matter, leaving behind just the rigid cell walls.

"The cell walls by themselves are capable of binding heavy metals," he notes. "By removing the living portion, you don't have to worry about people who might be allergic to the antibiotics produced by the living fungus."

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These beads of *Penicillium* mold may prove to be potent weapons against heavy metals.

Crusberg says the fungal beads may prove to be an ideal replacement for beads of resin that are now packed into columns and used to filter out heavy metals as industrial wastewater flows through. The resin beads are quite expensive and cannot be easily burned to enable recovery of the metals. The fungal beads, on the other hand, are inexpensive to produce and burn easily.

Currently, work in his laboratory is proceeding on several fronts. One undergraduate is studying the structure of the cell wall with the electron microscope, while a team of students is using neutron activation analysis to determine the structure's elemental composition. Yet another team is looking at how the cell wall binds to metals and whether the process can be reversed, perhaps opening the door to a reusable waste treatment system.

To produce fungal beads for these studies, Crusberg grows 2.5-liter batches in his lab, with each batch taking five days to mature. He says the 50-liter fermentor in the bioprocess technology laboratory will make this work much easier.

"Right now I'm at a disadvantage," he says. "I have to grow the fungus as fast as I can just to keep my students supplied. With the 50-liter fermentor, I'll be able to grow in one week a quantity of fungus that it now takes me more than three months to produce. It will enable me to begin a new phase of research and to begin thinking about producing these beads on a pilot scale."

Separating the Wheat From the Chaff

If you've ever mixed oil and vinegar, you've created a good working model for a technique commonly used to separate proteins from the complex broths in which they are produced. Just as oil and water, given time, will separate into two distinct layers, certain other liquids, when mixed together, will form a two-phased solution.

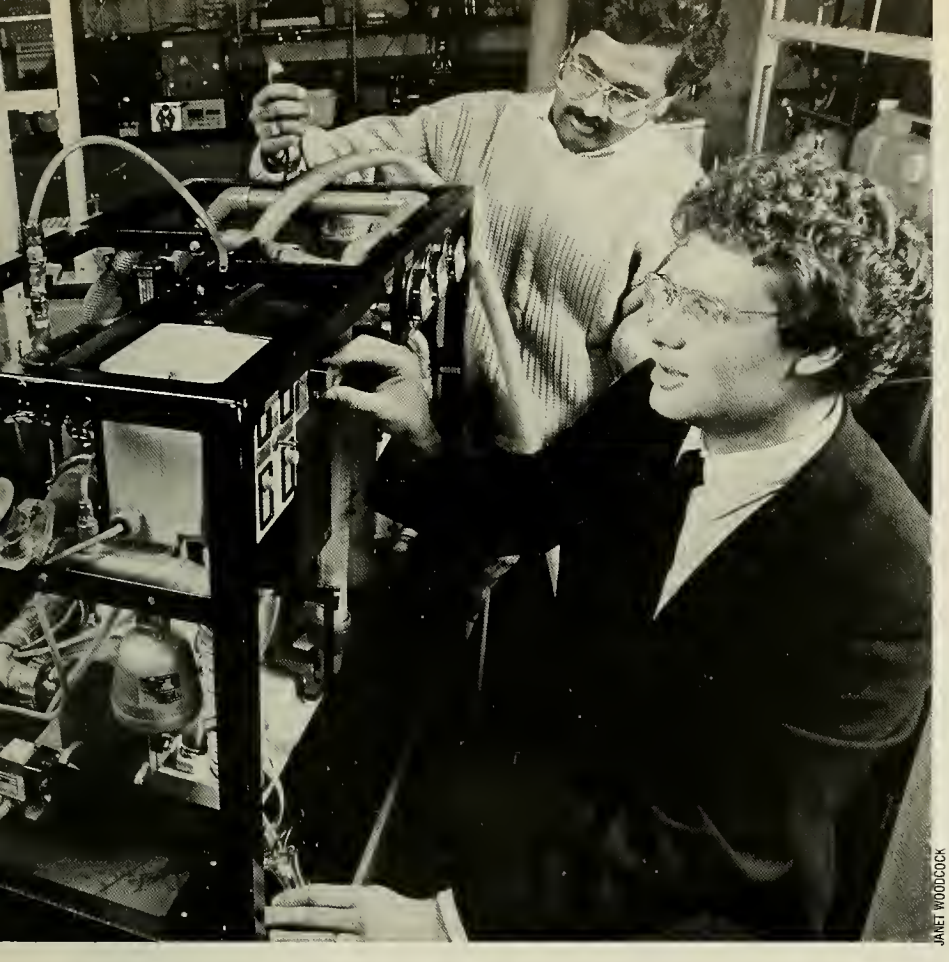
Proteins, when added to such a solution, will often show a tendency to migrate to one phase or the other. If the two phases are carefully selected, the protein can be drawn almost entirely into one phase and recovered, while the remaining portions of the broth concentrate in the other phase. In practice, it can take several such steps before the protein product is sufficiently purified.

William Clark (right), graduate student Aseem Bansal (left) and postdoctoral research assistant Vijai Pasupuleti use ceramic membranes to recover proteins.

Finding ways to make these liquid-liquid extractions more efficient is one of the focuses of the research of William M. Clark, assistant professor of chemical engineering. One approach Clark is exploring is called affinity partitioning, in which a molecule, known as a ligand, is temporarily attached to the protein. Since the ligand has a stronger attraction to one of the liquid phases than the protein itself, the separation can usually be completed in fewer steps.

Clark has also experimented with adding salts to the two-phased system. The salts break down into positive and negative ions that distribute themselves between the phases, creating an electrical potential difference across the border between the two liquids. The ions turn the solution into a weak battery and magnify the tug on the proteins, which have electrical charges on their surfaces.

"After experimenting with this ap-



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proach," Clark says, "we decided to add electrodes to the system to enhance the charge effect. Though it is less selective than affinity partitioning, this approach works faster and is less expensive."

A current student project Clark is directing seeks to employ this technique in a system that will continuously extract a protein product as a fermentation broth passes through a channel lined on both sides with electrodes.

While liquid-liquid extractions work well in some processes, other types of proteins can be removed more easily by passing the broth through a membrane. Working with WPI's Center for Inorganic Membrane Studies, Clark is evaluating separations done with membranes made from various ceramic materials.

Ceramic membranes have a number of advantages over the polymer membranes often used to recover proteins. They are more durable and less prone to developing leaks and can be more easily sterilized and reused.

While most of Clark's work is now done with small-scale systems, and with computer models, he says he hopes eventually to apply some of the techniques he develops to larger scale fermentations in the bioprocess technology lab.

Putting Cells in Their Place

While many of the industrial aspects of biotechnology have their roots in techniques long used by chemical engineers, biological processes have one source of problems that chemical engineers never have to deal with—the unique requirements of living organisms.

To survive, cells and microorganisms need a constant supply of nutrients and a stable, well-controlled environment. More critically, many types of cells simply won't manufacture proteins unless they are growing or if they are packed too closely together. Regulating the conditions under which cells are grown is a tricky undertaking, but one that is critical to the success of nearly all biotechnology processes.

One promising approach to controlling cell growth and development is the use of immobilized cell technology, according to Judith Miller, associate professor of biology and biotechnology. In this approach, cells are either confined with a screen, trapped within a protein membrane or enclosed in a gel.

The technique makes it fairly easy to control the delivery of nutrients and oxygen to cells and to recover their products. In addition immobilized cells tend to be more stable than cells suspended in a solution.

"This technology is still in its infancy," notes Miller, whose research concentrates on the physiology of cells that are restrained in this manner. "We are just beginning to understand how best to immobilize cells, how to predict what they will do, how to feed them and how to control their environment."

While immobilization has some advantages over letting cells float freely in a liquid, the technique does present its own problems, Miller says. Cells grown side by side can exert pressure on one another—up to three atmospheres, which can squeeze the cells and alter their biochemistry. When cells are stacked on top of one another, it can be difficult to get nutrients to those at the bottom of the pile. Material excreted by the cells—including the product of the process—can build up in a dense cell cluster and poison the cells.

Finding out how cells react to immobilization is difficult, since, as Miller notes, "it is difficult to probe the physiology of the cells without first freeing them, and then they are not immobilized anymore."

To overcome this limitation, Miller, working with David DiBiasio, associate professor of chemical engineering, grows cells in a thin layer of gel coated onto small plastic beads. The beads are then packed into a column through which fluid can flow. The fluid carries oxygen and nutrients to the cells and carries away their products. By comparing the input and output to the column, Miller is gaining insights to how the cells react to immobilization.

"We've found that immobilized and suspended cells are very different," she says. "For example, while immobilized cells don't grow any faster, they use a lot more carbon, which is unusual since carbon consumption is usually tied to growth rate."

Miller says the immobilized cells appear to metabolize the excess carbon and produce surplus energy. Since the production of protein is an energy-intensive operation, she says this may indicate that immobilized cells will produce more product than suspended cells.

WPI 1865 1950s 1990

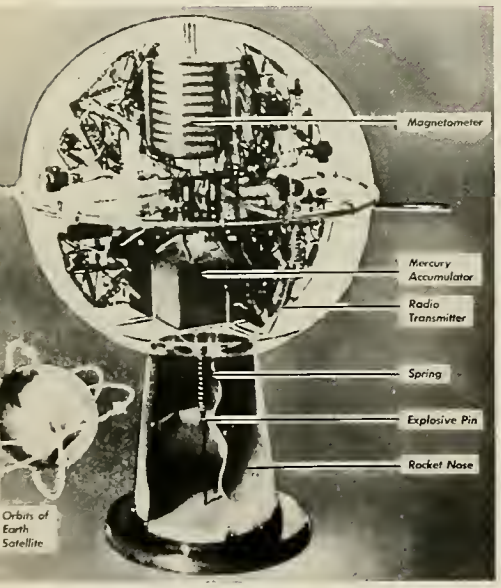
Timeline

A Journey Through WPI's First 125 Years

First of Four Parts

By Neil Norum

EDITOR'S NOTE: WPI marks the 125th anniversary of its founding this year. We thought it might be interesting to look back on the events, the ideas, the breakthroughs and the human dramas that made those years memorable—here on campus and around the world. So, like the protagonist in H.G. Wells' *The Time Machine*, we'll set our dials to a different point in the past, jumping steadily backward 30 years at a time in each issue of this year's *Journal* to see what our world was like. Our first stop...the late 1950s.



It was a time of great excitement and hope in the sciences. In 1957 the human race sent its first artifact into space—a tiny ball of beeping metal and circuitry called *Sputnik*. The United States answered the Soviet Union's space triumph by putting its first satellite, *Explorer I*, into orbit the following January. In May 1958 *Explorer I* detected a belt of intense ionizing radiation (named for pioneering space researcher James Van Allen) in the upper reaches of the atmosphere.

The National Aeronautics and Space Administration was born in 1958. By the end of the year the Defense Department announced long-range programs aimed at putting animals and people into space. At last, the dreams of WPI's own Robert Goddard '08 were coming true. "With the advent of the Space Age, man himself stands poised on the threshold of a new world," one writer proclaimed.

While the U.S. entered the space race in a big way (NASA chose its first seven astronauts by the end of the decade), the Soviets would make the competition keen. In 1959 they sent a rocket hurtling into the moon, an accomplishment one newspaper called "an event that will send repercussions down the corridors of time and have consequences hard to foresee." Later, a Russian space probe sent the first photographs of the moon's far side back to Earth.

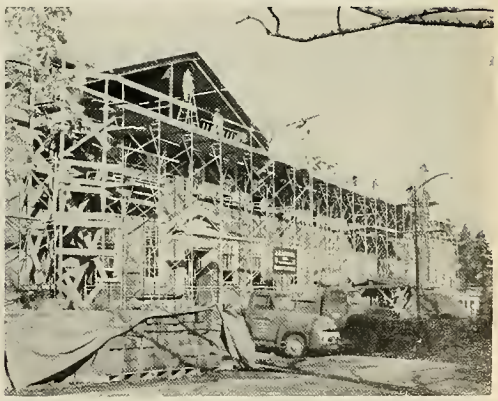
In 1958 scientists around the world participated in the International Geophysical Year, an 18-month period of exploration and discovery during which researchers from 66 countries conducted an unprecedented study of Earth and its cosmic environs.

In 1959 Philco brought out the first commercial version of a transistorized television—a portable, battery-operated receiver. Trade rumors had it that the Japanese would soon be exporting similar devices.

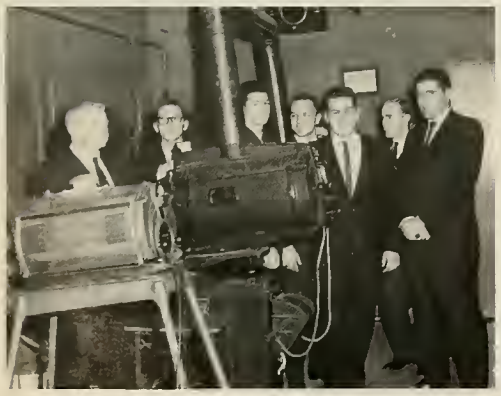
TV viewers in the late 1950s favored westerns, with shows like "Wagon Train," "Gunsmoke," "The Rifleman," "Maverick" and "Have Gun, Will Travel" consistently ranking among the most popular programs. Other favorites included "The Danny Thomas Show," "I've Got a Secret" and "The Ed Sullivan Show."

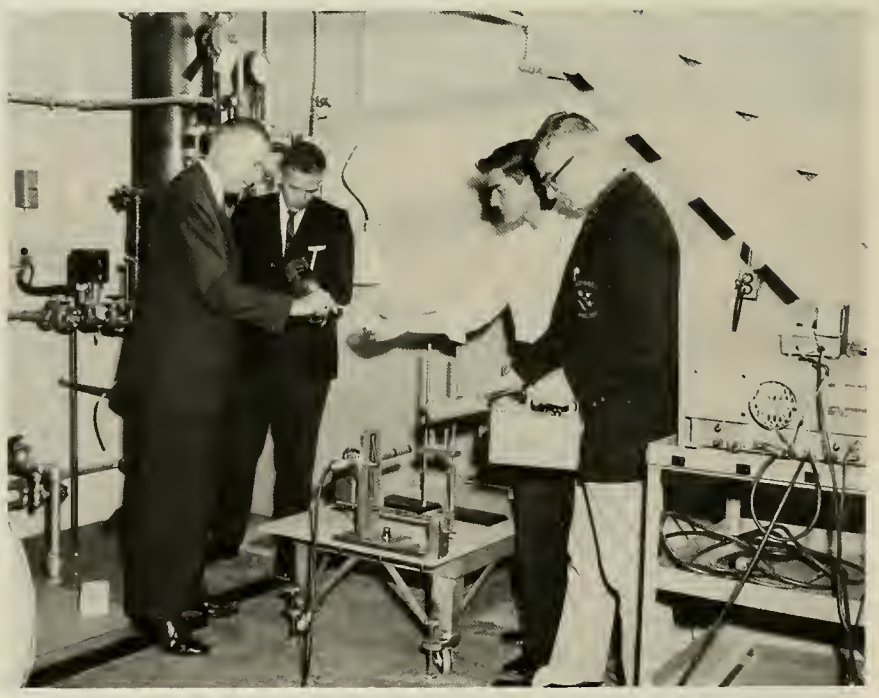
For their news, viewers turned to Huntley and Brinkley; for laughs their choice was Jack Paar. Loyal fans of TV quiz shows were shocked by the tales of widespread fraud, revealed daily before a congressional committee. As one writer of the time said, "Rigged quiz shows are indicative of easy-going moral attitudes prevalent in many circles besides advertising and entertainment."

People were dancing to the music of The Platters and cheering for Sugar Ray Robinson, who regained the middleweight boxing title in 1958 by outscoring Carmen Basilio in 15 rounds. They were



From the ground up: *Sputnik* (opposite) launched the Space Age. At WPI, buildings were rising: Morgan Hall (left), named for a family that gave WPI several generations of trustees—among them Philip M. Morgan, chairman of the Board in the late 1950s, shown in the top photo with President Bronwell, right, and trustee George W. Smith Jr. '15, left; and Olin Hall (above), a new home for physics.





New frontiers: (clockwise from top) WPI's first digital computer; breaking in the nuclear reactor facility; members of the arts society; and a new electrical engineering laboratory, part of renovations in Atwater Kent Laboratories.

also cheering for Tommy Bolt, who won the 1958 National Open Golf Championship, and for the New York Yankees, who defeated the Milwaukee Braves in the 1958 World Series.

Just as entertaining, in July 1959, was an American exhibit in Moscow, formally opened by Vice President Richard Nixon. His "debate" with Soviet Premier Nikita Khrushchev in the exhibit's kitchen made news worldwide. Khrushchev later spent 15 days in the U.S., though he couldn't go to Disneyland.

With their average 1958 earnings of $2.13 an hour (in the manufacturing sector, at least), U.S. workers were still buying Studebakers, Packards, DeSotos and Edsels, though the horsepower race was coming to an end as the Big Three automakers began introducing compact cars. One of the most promising inventions of the decade was the ground cushion vehicle, a car that moved on a pillow of air.

Alaska became the 49th U.S. state in January 1959, while the St. Lawrence Seaway became a reality a few months later. The peacetime draft was extended to July 1963. School integration remained a big issue in the South. The last of the federalized Arkansas National Guard troops were withdrawn from Central High School in Little Rock, Ark., in 1958; they had been keeping the peace there since the fall of 1957.

On the international scene, in 1957 the Eisenhower Doctrine called for aid to Mideast nations that resisted armed aggression from communist powers. The following year Egypt and Syria merged into the United Arab Republic and the European Economic Community was formed as the Treaty of Rome became effective (see page 30). Khrushchev became premier in the U.S.S.R. and Charles de Gaulle came into power in France.

Late in 1958 President Dwight Eisenhower, following a request for military assistance by the president of Lebanon, landed marines in that nation to preserve its independence. The following year the Dalai Lama escaped Chinese oppression by fleeing to India, and Fidel Castro seized power in Cuba.

In Massachusetts, Governor Foster Furcolo, along with the entire Democratic ticket, was re-elected by voters in the 1958 state elections. For the first time ever, the state senate had a Democratic majority. Among those holding on to their seats was John F. Kennedy, who was returned to the Senate.

Change was also in the air at WPI during the late 1950s. The curricula, staff and campus were undergoing a true metamorphosis. Mathematics became a degree-granting department and a $5.5 million capital campaign was under way to raise resources for the coming decade. Morgan and Olin halls were rising, while Salisbury and Atwater Kent laboratories were undergoing extensive renovations.

The changes in Atwater Kent were a reflection of a major revolution under way in electrical engineering. With the development of the transistor, electrical devices were getting smaller and smaller, and the vast open spaces of Atwater Kent were beginning to look quite empty. The renovations filled the electrical engineering building with laboratories dedicated to electronics of all sorts.

The first digital computer arrived on campus in 1959. It was an IBM 610 Auto-Point Computer with 80 storage registers, a video display, and paper-tape readers and punchers. It could multiply two 31-digit numbers in three-quarters of a second. At the time, WPI owned two analog computers and had limited access to a large digital computer at MIT. In the late 1950s a committee was formed to study the possibility of establishing a computer center on campus, something that would come to pass within a decade.

WPI took another major leap into the realm of a relatively new science when it installed a research nuclear reactor in the Washburn Shops in 1959. The 10-kilowatt, open-pool reactor was the first such facility in New England.

Looking ahead to the next decade, President Arthur B. Bronwell reaffirmed the mission of the college. He said WPI must continue to be motivated by "sincere devotion to the cause of seeking out talented young men and of providing a scholarly environment, with broad cultural opportunities as well as depth of understanding in the sciences and in engineering, which will prepare them to contribute distinctively to the advancement

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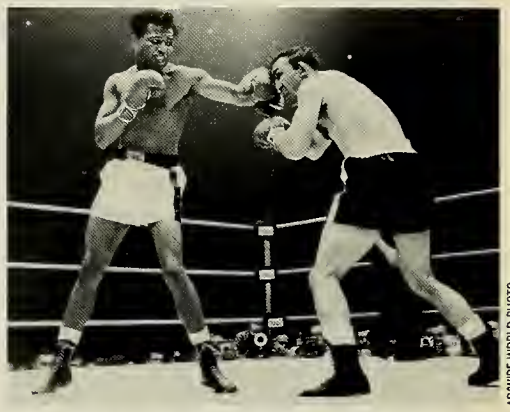
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Winners: Fidel Castro (top) took charge in Cuba; Sugar Ray Robinson regained the heavyweight title by defeating Carmen Basilio.

Student life: (from top) Freshman indoctrination, 1959; the football team on the way to a nearly undefeated season in 1958; the rigors of academic life at WPI.

of the welfare of mankind."

During the 91st Commencement in 1957, 209 students received their degrees. Then, as now, the top majors included electrical engineering (71 graduates), mechanical engineering (56), civil engineering (35), and chemical engineering (32).

Despite a recession, the class of 1957 could look forward to nearly unlimited opportunities upon graduation. As the September-October 1957 *WPI Journal* put it, "He [the WPI graduate] is not influenced by many offers alone...he is influenced by opportunities offered for continuing education." Graduates could also expect to earn an average monthly salary of $455.

"The students on Boynton Hill took a long look at the world in which they had grown up and realized that half of the jobs available to them at graduation had not even existed when they were born," wrote Mildred Tymeson in *Two Towers,* WPI's centennial history. "The pace of technological change was almost frightening to the parent, the trustee and to some of the teachers—but not to the brave young man of a contemporary world. The drum he heard was his own pulse."

The following fall, WPI's all-male student body included 970 full-time and 54 part-time students, having increased 25 percent over the previous two years. There were 136 faculty members and tuition was $1,100 per year. All these numbers had grown significantly since the college started classes in 1868, the *Journal* noted. The first class numbered just 32 and was taught by fewer than half a dozen faculty members. Back then all students attended for free.

Among those enrolled in 1958 were students from 16 nations. Still, most students came from closer to home: 19 percent from Worcester, another 19 percent from the rest of Worcester County and 28 percent from the rest of Massachusetts. There were 275 new freshmen that year who listed among their interests football, baseball, track, basketball, drama, yearbook, student council and class office.

The normal confusion of the first day of classes was exacerbated when a seven-week strike delayed the opening of Morgan Hall. "Half a loaf [is] better than none," the *Journal* noted. "Sixty-seven freshmen were moved into barracks-like quarters on the basketball floor in Alumni Gymnasium. Riley housed the largest number of freshmen in [its] history with four to a room."

More than 400 students got together that year to form an arts society to sponsor dramatic productions. The wrestling club received permission to become a new student organization on a trial basis. The football team nearly had an undefeated season, losing just one game—to Middlebury College—by one point. Monthly College Day convocations were resumed after a long absence to give students the opportunity to keep abreast of developments and ideas outside the confines of their college curriculum.

The Tech Old-Timers was founded that year; it held its first official meeting in November. Membership was open to alumni, trustees and faculty members who were at least 65 years old or retired, and who lived within easy reach of Worcester.

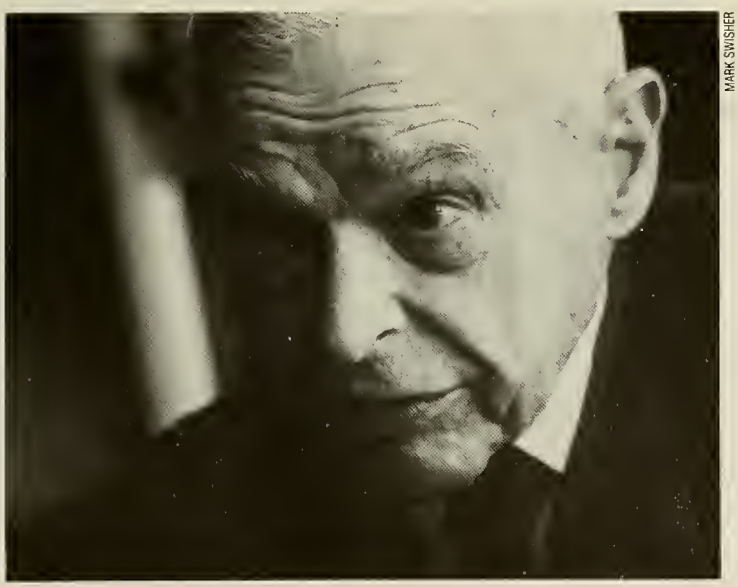
By mid-1958 an 11-member faculty committee released the results of a two-year study of factors affecting students' scholarly performance, motivation and morale. The committee had examined the grading system, student-faculty relations, fraternities, contact hours (the time faculty members spend with students), extracurricular activities and facilities.

WPI's grading policy, the committee said, was unique. "Very few colleges use a numerical grading system....Provision for 'conditions' and 'make-up examinations' is practically nonexistent." The committee said good student-faculty relations aided the learning process, and fraternities, which housed 70 percent of the student body, played an important part in the life of the college.

"They have provided housing, sparked the campus social life and actively supported extracurricular activities," the committee report noted.

The group pointed to a need for a balance between contact hours and time available for reflection, study and preparation, and noted that "the Institute has been able to provide excellent facilities...and [it is] hoped that future plans will take into account provisions for a central library."

As the decade neared its end in 1959, the editors of the student yearbook, *Peddler*, aptly reflected on the events that had changed the college. "What is this old school coming to? New buildings, record enrollments, headlines in sports as well as education....we live in the midst of history and don't know it's being made."



MARK SWISHER

Arms and the Man

"...if all the NATO countries suddenly decide there isn't any need for military forces, we may find that we've grasped defeat out of total victory."

Paul H. Nitze brings a special perspective to the dramatic changes that are sweeping Eastern Europe and the Soviet Union. Here the distinguished arms negotiator, former Secretary of the Navy, and former Deputy Secretary of Defense reveals his views on reunification, revolution, arms reductions, and other economic and military matters of the post-Cold-War world. New York writer Joe Levine conducted the interview on December 15.

Question: You have variously described the recent upheaval in Eastern Europe as "the revolution of 1989" and "the collapse of the Soviet empire," and you have called it just cause for celebrating the "triumph of America's postwar policy of containment." Do you believe that the 45-year period of viewing the Soviet Union as our enemy has ended?

Answer: I would put it differently. I think a change has taken place in the Soviet Union that is definitive, not reversible. They've lost confidence in totalitarian Communism—not in Communism per se, but in what the doctrine has traditionally held, i.e., that you wouldn't have peace until the world is a Communist world and unless you got rid of class tensions in the kind of world in which liberal democracies exist. That view is gone. And yes, that is cause

for celebration.

But I'm not sure it's right to say that we viewed the Soviets as the "enemy." These people considered *us* the enemy, you see—they had to get rid of us in order to achieve what they defined as peace.

Q: Do you think that, under Gorbachev, the Soviet view of us as the enemy has changed irreversibly?

A: Yes. I do. But having said that, I think it would be a mistake to tie our policy too closely to a single individual. We tried that in Iran with the Shah and in China with Chiang Kai-shek. In both cases, it backfired badly.

Q: Then you don't believe Gorbachev can last?

A: He faces immense problems, and his efforts to overcome these problems have for the most part fallen far short of success. He hasn't been able to introduce market forces as he had originally planned. In the meantime, the economic situation in the U.S.S.R. has radically worsened. His efforts to restructure the Party and the government have had some success in increasing efficiency and responsiveness. But the system still is subject to his ultimate personal control, and without that ultimate control, the situation could become unstable. At the same time, the problems with internal nationalities have grown far beyond anything Gorbachev anticipated. And the limits he earlier put on the extent of reform in Eastern Europe have been swept away by the political forces let loose by the discrediting of totalitarian Communism. I don't believe he can cure both the problems with his economy and the problem with his nationalities. By trying to deal with those two things at the same time—well, I can see the country getting into really serious difficulties. So, no, I don't give him much chance of being able to last more than five years. Either he'll get discouraged, or someone will take power from him.

Q: Is it in our interest for Gorbachev to succeed, and should we give him economic aid?

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"The Master of the Game": *Paul Nitze (center) has played a role in national security decisions under every president from Roosevelt to Reagan. He met with Secretary of State George Schultz and Soviet leader Mikhail Gorbachev in Moscow in October 1987 to set up the third Reagan/Gorbachev summit.*

A: We know Gorbachev and have had experience in dealing with him. Any successor would be bound to present greater uncertainties. I agree with those who argue that the success of *glasnost* and *perestroika* is in our interest. I believe they would likely lead, in the long run, to a more open, prosperous, less militaristic Soviet Union—one that evidenced greater respect for individual and national rights, and played a more cooperative and less ideology-driven role in resolving international problems peacefully.

I don't believe that economic chaos in the U.S.S.R. is in anyone's interest—it's too important a part of the world. Nevertheless, I don't recommend that we provide extensive material economic aid at this time, although giving them contingent support for most favored economic treatment would be a different matter. At some time in the future, it's likely that the Soviet part of the world will be economically so organized as to be able to take advantage of modern management and technical advances. But until the Soviet leaders cast off the ideological barriers that prevent them from accepting private ownership of land, of their homes, of small businesses, I see little prospect of an economic revival. Aid—when there are ideological barriers to its proper use—is generally ineffective.

At the same time, there seems to be every indication that Gorbachev is trying to move back to encouraging centralized Communist discipline. He certainly is making every move in the direction of having the press be more friendly to him—and he's doing it with some degree of threat involved, too. He's changed the leadership of most of the leading newspapers. The fellows he hasn't changed are very conscious of the fact that he has the power and maybe the disposition to get rid of them. So I think everyone in the Soviet Union is feeling the imminence of this greater discipline, or the threat thereof. Now, whether it will be imposed in a more direct way, and whether it will ruin Gorbachev or help him, I can't tell. In the meantime, though, I think we should be positioned to deal effectively with his successor, should a change of leadership occur.

Q: Who do you think that successor might turn out to be?

A: Well, 52 percent of the Soviet population are Great Russians, and I think they feel very bitterly about the better life and the fewer sacrifices they think the Georgians, Armenians, Muslims, and so forth have had to make. They think that, "we, the Great Russians, have supplied 90 percent of the sacrifice, have done most of the work, and what is necessary for us is to have a point of view of nationalism of our own." That's why this anti-Semitic, rightist group called Pamyat is now growing by leaps and bounds. I gather from people who have been in the Soviet Union recently that if there were an election in the Russian Republic, it would go to Pamyat. I'm also told that a highly placed official in the Soviet military is a leading member of Pamyat. The leading publicist amongst the Great Russians today is a fellow with the extraordinarily familiar name of Rasputin. He is by far the most popular Russian author of today, I'm told. And he believes that the Russian Republic should secede from the Soviet Union and become an autocracy—this is the main drive of all his publicity.

So I don't know, really. It's not yet clear what kind of a political structure would be able to take power from Mr. Gorbachev, or what kinds of threats it could present. I do believe that whoever

did take over would be forced by events to follow a foreign policy not too different from Gorbachev's. The changes of the last few months have created such an alteration in the world scene that Gorbachev or any Soviet leader will have to adjust to it. And any Soviet leader will be constrained by much the same panoply of internal problems that have so substantially influenced Gorbachev's policies.

Q: Given that we would prefer to see Gorbachev remain, shouldn't we be encouraging the other nationalities within the Soviet Union that want greater political autonomy or even independence?

A: I don't see any way to resolve that dilemma in a completely satisfactory manner. Our values come into conflict with our pragmatic interests—we support the aspirations of all nationalities for greater self-determination, but we must also beware of the great danger that might arise if ethnic conflicts in the Soviet Union should get out of hand. The possibility of civil war in a land where tens of thousands of powerful nuclear weapons are stored is not to be taken lightly.

What I would say, for starters, is that we should distinguish between the Baltic states and other nationality groups. The Baltics were absorbed against their will many years ago, and we've never considered their annexation legitimate. To change that view now, in order to help Gorbachev survive, is in my view erroneous in principle, and apt to be counterproductive in practice. So I disapprove of recent U.S. statements discouraging the Baltic states from pursuing independence at this time.

But I'd recommend a more cautious attitude toward the Georgians, Armenians, Azerbaijanis, and others. We should maintain our support for self-determination in general, but we should avoid giving encouragement to secessionist movements. The primary thrust of our policy should be to object on humanitarian grounds to any use of excessively harsh means to suppress these groups.

Q: Might not that distinction be lost upon those other ethnic groups? And if they persist in trying to secede, couldn't it unleash chaos in the Soviet Union?

A: It could, but I don't think it would be the cause of chaos. As I've said, I think the basic cause of the revolution that is taking place this year is that totalitarian Communism has fallen into disrespect, and not only among the outside people, but among the people who have been running it in the past. And that's the most important point. I don't think the Czechs, for instance, would have gone the way they've gone if they really thought that the Russians and the hardliners in Czechoslovakia had the determination to do now what they would have had the determination to do three years ago. The same goes for the German Democratic Republic, where the Russians have close to 350,000 troops right there, which could certainly overpower anybody that resists them.

Q: Let's leave the Soviet Union for a moment, and look at the other Warsaw Pact countries that have recently seen such huge political changes. You were perhaps the key person in shaping the Marshall Plan after World War II. Do you think the United States should be offering similar aid to Eastern Europe?

A: I would suggest that the most difficult, and also the most urgent, objective for us and our allies right now is to demonstrate that the states that have for some time been under the firm and destructive control of totalitarian Communist regimes can make the transition to free and successful governmental systems, systems that are responsive to their people. Poland is the immediate problem, but Hungary, East Germany, and Czechoslovakia are not that far behind.

I think Poland, because Catholicism was not successfully suppressed, is culturally pretty sound. Its political orientation toward the West is also established. Are there sufficient cadres to make noncentralized agriculture, commerce, and industry work? It will take a great deal of Western help to make that possible.

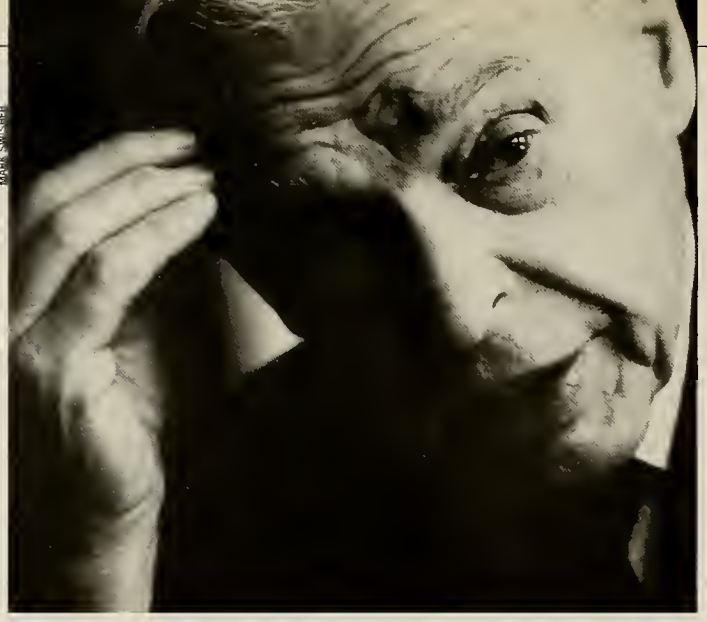
Similarly, I see no great issue regarding our policy toward other Warsaw Pact states that are attempting, or may in the future attempt, the transition to market economies and representative governments. They deserve our help. Now, what should our response be if, despite the transition, they wish to remain members of the Warsaw Pact, whether to avoid Soviet disapproval and possible counteraction, or for some other reason? I still see little reason for us to object, because I don't believe they would give the Soviets cooperation that would materially affect our security interests, or that of our allies. I don't think it's possible for the Russians ever again to count on any worthwhile military assistance from the Poles, the Hungarians, the Czechs, or that part of the world.

Of course, a new issue arises with West Germany taking the lead with aid to Poland, and later with aid to East Germany, Hungary, and Czechoslovakia. This points to a primary role for Germany, not just in respect to reunification, but in Central Europe as a whole. West Germany today is the strongest country economically on the continent, and second only to the Soviet Union in non-nuclear capabilities. With reunification, and with the development of close ties with the Central European countries, Germany's position in the European Community could become dominant.

Q: And what is your view there? Should the United States support reunification?

AP/WIDE WORLD

Reunification: *The dramatic upheaval in Eastern Europe—symbolized by the dismantling of the Berlin Wall—is cause for celebration, says Nitze. But he cautions that it's too early for the U.S. to begin making significant cuts in defense.*


MARK SWISHER

What are people really afraid of when they talk about a dominant Germany? Is it the threat to the established economic order in Europe and to the NATO alliance—or does it have to do with Germany's history as an aggressive military power?

A: First of all, I doubt that the United States should, or can, effectively oppose reunification. The task of dealing constructively with burgeoning German power must largely be that of the Atlantic Community, although there is a necessary role for the United States as well. This winter the European Community countries met in Paris at the invitation of President [François] Mitterand to discuss the possibility of German reunification, and they all agreed, including [West German Chancellor Helmut] Kohl, that the time had not yet arrived. But within a week, political developments changed the scene so dramatically that Kohl altered his position. Now he accepts as inevitable some form of unity between the two Germanys. And now the European Community appears to have given its approval.

What are the fears? I don't know. I think that history does carry some importance. When you're trying to interpret what may happen in the future, I wouldn't ignore it. You're quite right that the recollection of what happened in the past is going to color people's attitudes. It will. So, if we're talking about the recollection of Hitler and the Kaiser and all that, I believe that would be there. But I don't think it would be the dominant consideration in most people's minds. I think the dominant consideration would be: What do people think is going to happen in the future and is that going to help or hurt us in achieving the kind of world we want? But of course, all these things require greater precision to talk about them intelligently.

Q: I'd like to switch from economic matters to military ones, if I may. Do you think, given the recent changes in Eastern Europe, that the United States can or should start making significant cuts in its defense budget, as many people have been saying?

A: I think it's too early. We should not lose sight of the dangerous forces that will remain even if we succeed in concluding START [Strategic Arms Reduction Talks] and CFE [Conventional Force Elimination] negotiations as now projected. As long as 30,000 large and potentially destabilizing nuclear warheads exist in the Soviet Union, someone in the West will have to accept the task of deterring their use should the Soviet leadership become more irresponsible. I believe that task necessarily falls to us.

So I really was surprised at [Secretary of Defense Richard] Cheney's statement that he was doing his budget review on the judgment that there was no longer a threat. I'm not sure that's quite how he put it, but that was certainly his implication. I mean, good God, we all want to reduce military expenditures, and so do our allies. The Germans would certainly like to reduce their draft and their expenditures for forces; so would the British and so would the Belgians and so would everybody else. And I think they all now feel that they don't have the grounds for resisting, so that if all the NATO countries suddenly decide there isn't any need for military forces, suddenly we may find that we've grasped defeat out of total victory.

You see, one of the aims of Gorbachev's reforms—the only one he has really achieved—has been to reduce the appearance of a threat from the U.S.S.R., and thereby release certain inherent centrifugal forces in the West. And this is certainly one of the centrifugal forces, and it drives the alliance apart.

Q: I take it, then, that you believe NATO hasn't outlived its usefulness?

A: Certainly not. There should be an organizational structure through which we consult with our allies about maintaining the bottom line of our defenses. NATO would appear to be an excellent such organization, and we and our allies should resist any suggestion that it be disbanded, regardless of whether or not the Warsaw Pact remains intact.

Q: What about our posture in strategic arms and conventional force negotiations with the Soviets? Should we be willing to make any larger concessions than previously planned? Or, alternatively, have we got the advantage right now, and should we press it?

A: It is my view that even if we were to conclude a START agreement along the lines we have been striving for for some time, it would not provide adequate assurance of stability for the long term. As I've said, there are some 30,000 nuclear warheads and thousands of destabilizing delivery systems in the U.S.S.R. Our current position does not propose that any nuclear warheads be destroyed or that there be cuts of sufficient magnitude in destabilizing delivery systems to provide confidence on long-term stability.

Meanwhile, the Soviets are modernizing their most threatening long-range nuclear system, the heavy ICBMs [intercontinental ballistic missiles] with a new system called the SS-18 Mod 5. These will be the most modern, most destructive, and most potentially destabilizing systems in the world—twice the weight and size and capability of the MX. They go right to the heart of the security of the United States. I think the Russians deployed the first one at the beginning of last fall, and it looks as if now they'll get the whole 150 deployed before the middle of next year [1990]. They're really going at it hammer and tongs.

Gorbachev has said that the tensions in Europe over the last decade were caused by an erroneous decision by the Soviet Union to deploy other powerful missiles, the SS-20s, in the center of Europe without considering the anxiety it would cause to the continental European NATO countries. He's admitted it was an error because it stimulated Europe to deploy the GLCMs [ground-launched

cruise missiles] and Pershing IIs. He's said that it was his realization of that error and his recognition that the lesson applied more broadly that had caused him to propose unilateral reductions in conventional arms in Europe and much greater reductions if NATO were to agree to reciprocate.

So I believe we should now point out the analogy between the earlier Soviet error in deploying SS-20s in the center of Europe and their current error in insisting on maintaining and modernizing their heavy ICBMs. In the past, you see, we didn't ask this kind of thing of the Soviets, not because we didn't believe we were right, but because we thought it would overburden the negotiating situation. But I think it would be in both our interests now. The SS-18 Mod 5 is a poisonous plant in the garden of presumed favorable U.S.-Soviet relations that one hopes for. As long as that poison plant is there, it's going to be very difficult for us to be understanding of the Soviets. We're going to have this lurking reserve in our mind, that they are refusing to deal with what is the main threat to our basic security. And they shouldn't do that, and we ought to ask them not to. But, of course, we must recognize that it is unlikely that Gorbachev will agree.

Q: What about the destabilizing effects of our own Strategic Defense Initiative? Should we still continue to fund research for SDI?

A: I don't think it's possible for SDI to be deployed within the foreseeable future. I don't think the technical difficulties have yet been solved in any way, and the law now provides that they must be before we begin the deployment of such a system. Congress is adamant about that. So I don't see any prospect of SDI becoming a destabilizing system.

Nevertheless, I do think we should continue research on SDI, because if it were to turn out that there is an effective way of operating a space defense system, we'd better know about it. The Soviets have put more work into the SDI field than we have over the years, and I don't think we want suddenly to be surprised by having an effective SDI program suddenly appear on the scene. At the present time, I'm not prepared to say I'm convinced that the potentiality of its being feasible is zero. To have it in ten years, I think, is close to zero. But certainly if you're talking about the longer range future, you can't tell. You've got to do research on it in order to tell.

Q: At Malta, Gorbachev showed Bush a map with our bases on it. I wonder if, apart from our strategic arms negotiations, you feel that there should be any change in our agenda for closing or maintaining any of those bases.

A: Well, I've seen that map before—long before. Three or four years ago, the Soviets produced such a map, and it was absolutely silly, I thought, because it construed the presence of a single U.S. naval vessel in a harbor as making a base. It's the way the Soviets do these things, you know. They use words in such multiple uses, take them out of context, and give an impression that it's something which it isn't. I get worried about these tactics.

Q: Should our bearing toward China perhaps be changing, what with the return of hardliners in Beijing and the fact that we no longer need the "China card" the way we have in the past?

A: My view is that we ought to continue to try to maintain relations with Communist China. The hardliners were always there; it isn't as if anybody's changed. They've put down the students, to everybody's great regret, but that having been done, the Chinese hardliners are still there. They were there before the students began to riot, and I think they'll be there again. We've got to deal with China. After all, there are a billion people there—a billion intelligent, productive, hardworking people who make up a pretty important element in the world. So our policy toward China doesn't go from 100 percent to zero—it must be a continuing concern of our foreign policy.

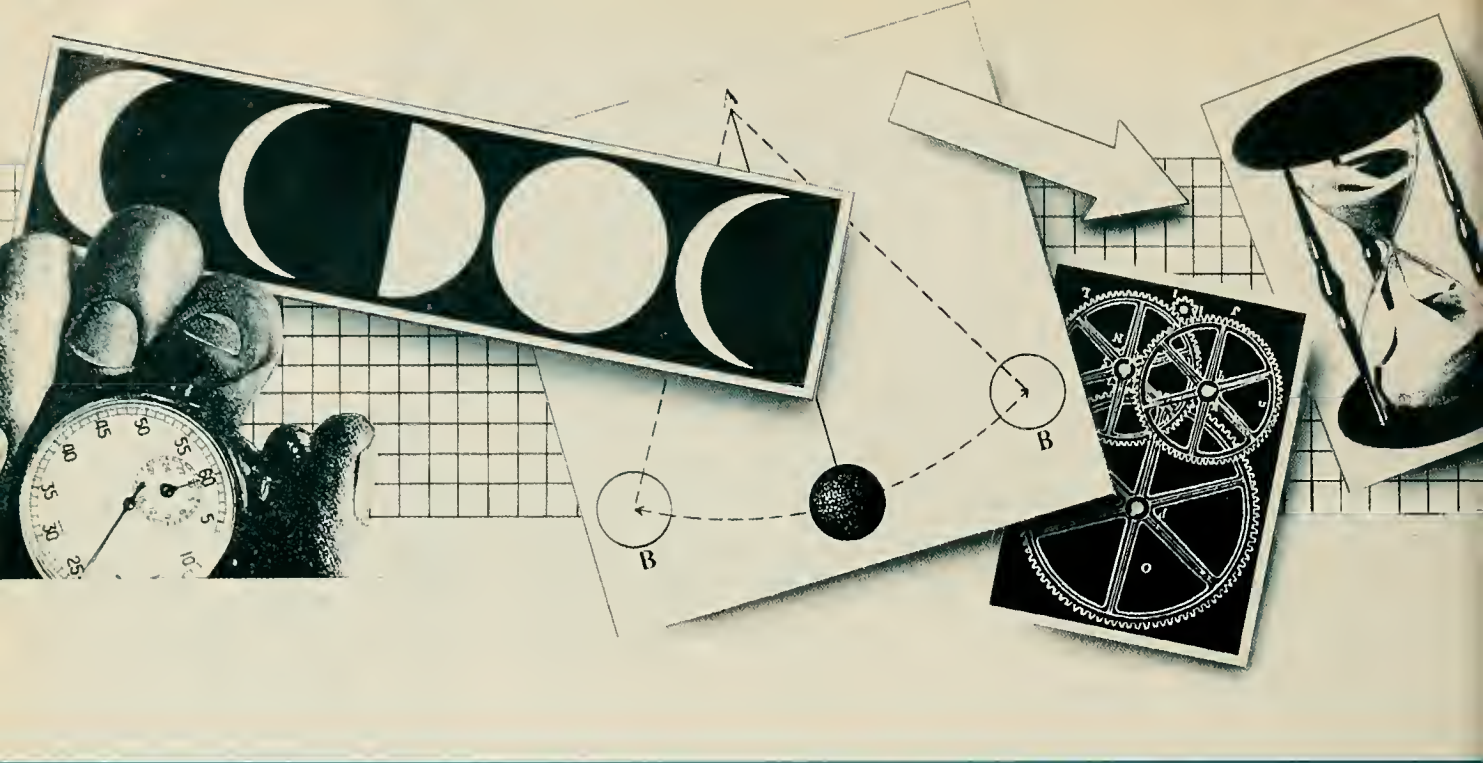
Q: Do you expect that China will eventually undergo an upheaval similar to that in Russia?

A: Of course, the Chinese Communists went at their problems somewhat differently than the Soviets did. They put the first priority upon curing some of their agricultural problems. They had really very great trust in the agricultural segment of their economy, and they did not find it difficult to delegate to these cooperatives really very great authority for self-management. That whole agricultural revolution in China worked well, while it didn't work well in the Soviet Union. And that gave the Chinese very much of a leg up in trying to do something about the industrial part of their economy. But I don't think they've done very well with that, in part because they don't trust their own people in the factories. They try to run all the factories from the ministries in the center, and they don't do that well. But it's just a different community.

From the ideological standpoint, the Chinese Communists also feel that there has been a distinct discrediting of the whole theory of Communist controls in the world, and that they're up against a different psychological and political problem that they can only now handle by going into complete isolationism. But whether they can continue that for long, I doubt. I think there is simply a delayed time bomb in China.

AP/WIDE WORLD

A "delayed time bomb": *Despite the student bloodshed in Tiananmen Square last spring, Nitze believes the United States should try to maintain relations with hardliners in Communist China. Nitze's legendary skills at negotiation are one reason Johns Hopkins University recently renamed its Washington D.C.-based School of Advanced International Studies in his honor.*



COUNTD

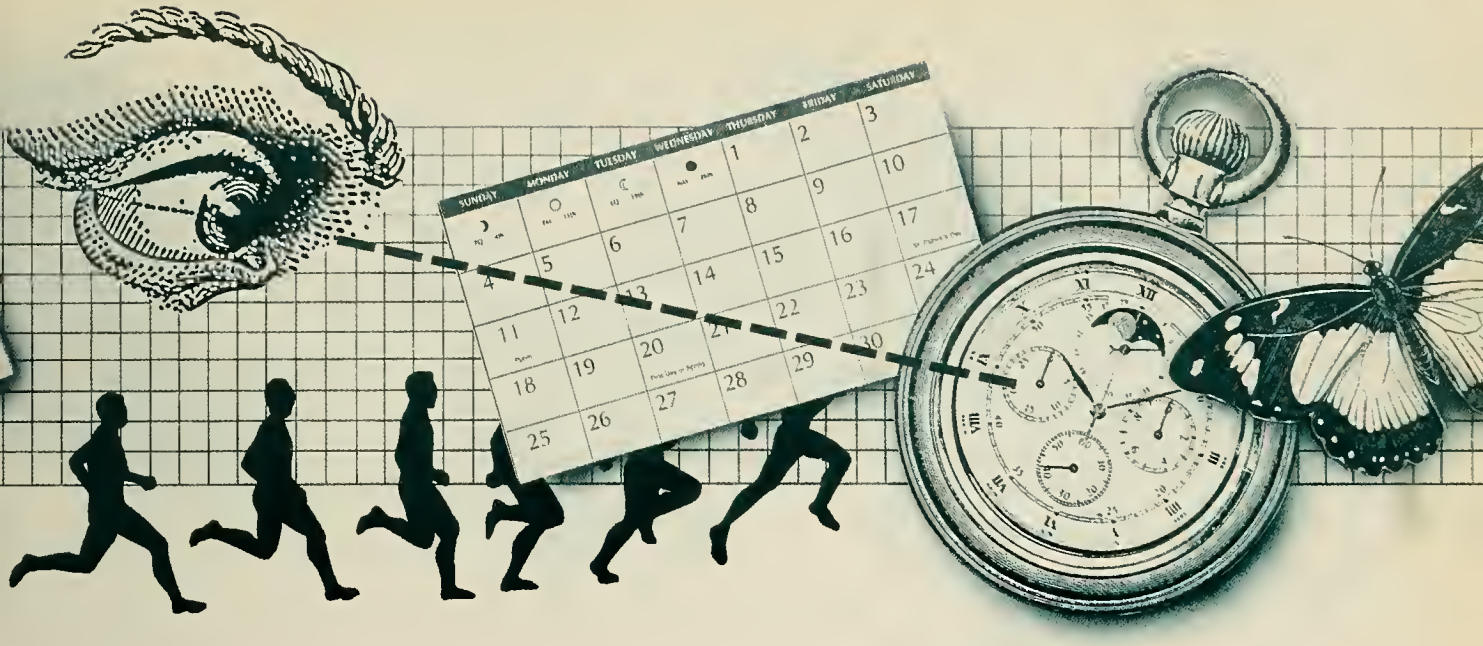
DIGITAL WATCHES BLINK OUT THE HOURS, minutes, and seconds. Other instruments dissect time into incomprehensibly small bits. The doomsday clock ticks loudly—on ozone depletion, acid rain, AIDS, to name but a few crises. Our own age's images of time are increasingly precise yet alarmingly frenetic.

In only 10 years a new millennium comes to pass. What will the 21st century bring? Which of the 20th century's problems most need to be solved before then? As we began to think about such questions, we asked a few faculty members what their own views might be. What one issue in their respective disciplines do they believe most needs to be addressed? And how should the United States go about dealing with that issue in the next 10 years?

Their responses are by no means a definitive summary of the challenges a post-industrial world faces. But they provide insights into several vital concerns in ethics, economics, the environment, science, and society.

Perhaps you'd like to send the editor of this magazine a letter with your own thoughts on what other problem you believe most needs to be resolved by the year 2000.

—Donna Shoemaker



O W N T O

2000

Six faculty members tell us what pressing issues in their fields most need to be addressed during the coming decade.

By Sue De Pasquale

ETHICS AND GENETICS: *Caveats on decoding the human blueprint*

The Human Genome Project, launched last January by the National Institutes of Health, is a $3 billion effort to map the chromosomes and decipher the complete blueprint for making a human being. Once the genetic recipe for humankind is decoded, say optimistic researchers, cures could soon be on the way for such single-gene disorders as cystic fibrosis, muscular dystrophy, sickle cell anemia, and Huntington's disease. Farther on down the road will come genetic cancer therapies and cures for autoimmune disorders and rheumatoid arthritis, they predict.

Tom Shannon

Tom Shannon, an ethicist at Worcester Polytechnic Institute, is aware of the sunny forecasts and heartened by them. He cautions, however, that this massive project will raise thorny ethical questions that should be addressed now, before the lab results are in. "If we succeed in mapping the human genome, we will get a good fix on a person's genetic profile, giving us access to some of the most intimate aspects of that person," says Shannon. "That information could be used in a very discriminatory fashion."

Who is going to control that knowledge, and what purpose will it serve? What happens if insurance companies or potential employers can predict the genetic illnesses that will befall us? "The issue of control is very significant and a major question we have to deal with," Shannon says.

The ethicist is also disquieted by the prospect of genetic "determinism" and "stereotyping." Many believe the potential is there for researchers to discover predispositions to a host of mental and emotional disorders, and eventually to arrive at genetic combinations that affect, say, intelligence, ambition, or aggression. The danger lies in assuming that genetics alone influences these characteristics, thereby discounting the influence of other factors like environment, says Shannon.

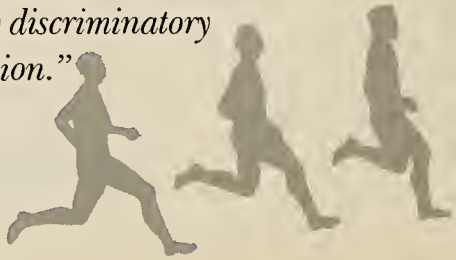
"We don't want to make the genetic information the exclusive basis for how we treat people," he says. "A person is more than his or her genes. They are not the sole determining cause of who we are.

"I'm concerned that an individual may be predetermined to be a particular kind of person; [that people will say] this person has genetic profile 'X,' therefore he or she is unacceptable to do certain kinds of things. It's possible for this information to lead to a stratified society, in which people are grouped according to their genetic profiles."

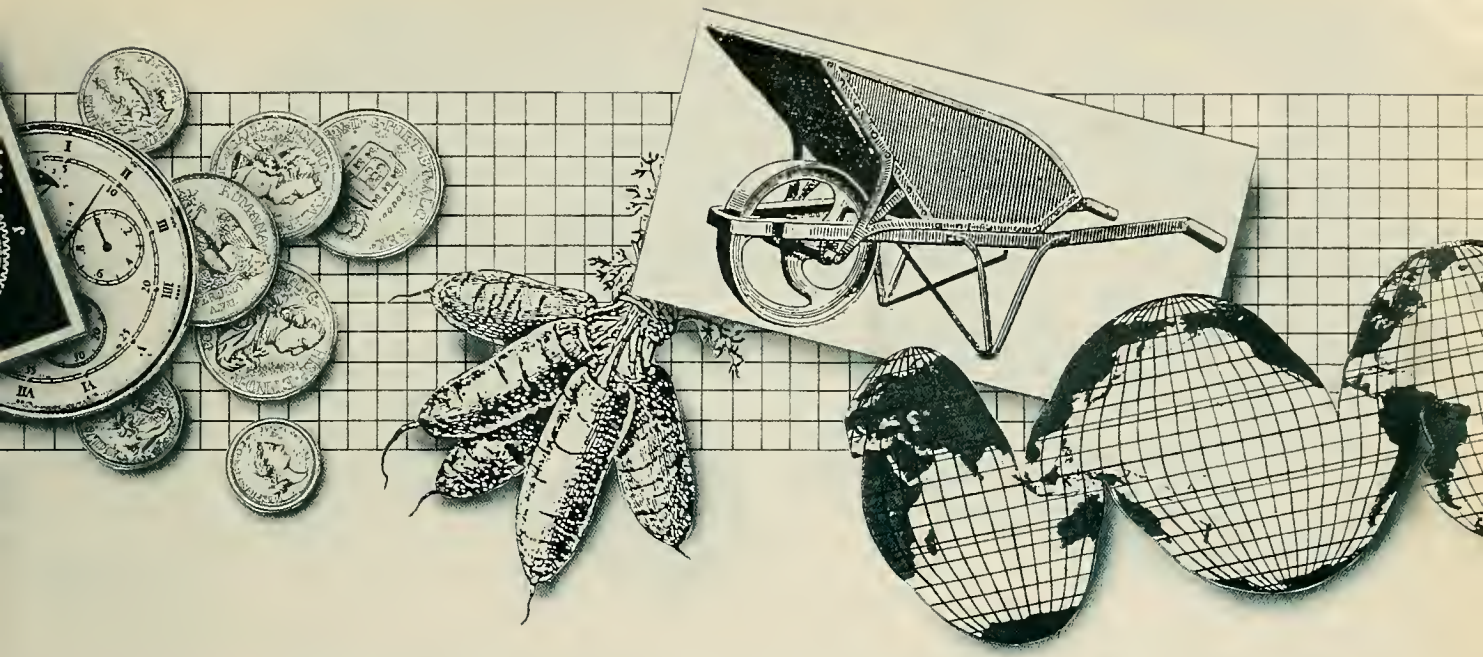
Worse, says the ethicist, is the eugenic potential inherent in genetic engineering. What will happen if technology eventually allows geneticists to manipulate the genetic blueprint—to alter gene combinations that influence hair color or intelligence or musical ability?

The bottom line, he says, is that as incredibly promising as the Human Genome Project might seem, it will create "costs and burdens" that have to be borne. "There are legitimate questions that ought to be asked," says Shannon. "The people who ask them are not trying to stop scientific progress. They're just trying to ascertain its directions."

"If we succeed in mapping the human genome, we will get a good fix on a person's genetic profile. That information could be used in a very discriminatory fashion."



Sue De Pasquale is assistant editor of the Alumni Magazine Consortium.



THIRD-WORLD AID: *Small loans yield big returns*

When it comes to promoting development in the Third World, we need to "think small," says Kenneth Grundy. Large-scale foreign aid efforts too often get diverted by kickbacks, administrative mismanagement, and theft. Rather than helping the poorest of the poor, American dollars end up fattening the coffers of the ruling elite, says the professor of political science at Case Western Reserve University.

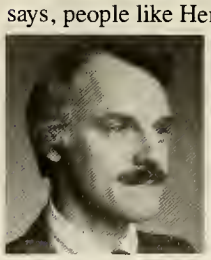
"By thinking in big terms we work with big institutions—governments and banks—and we end up strengthening the very institutions that take advantage of the 'little people,' " he believes. "That's why micro-enterprise holds out such promise for the future."

Grundy favors making small loans available to family "cottage industries"—like a Bangladesh woman who canes bamboo stools or a Nicaraguan family that raises vegetables. A loan of just $50 is all most would-be entrepreneurs need to pull themselves out of poverty and become self-supporting, according to Grundy. Unfortunately, traditional bank lending programs won't bother with such small amounts. Without collateral or co-signers, villagers who want small loans must rely on local moneylenders, who usually charge usurious rates.

In areas where small loans have been made available, "their successes have been legion," says Grundy. He offers the case of Santos Hernandez, an El Salvadoran mother of four who had no husband and no education. She farmed three-quarters of an acre, selling the vegetables on the street. When El Salvador's civil war forced her family into a relief camp, Hernandez lost her sense of dignity as well as her independence.

Four years ago, she heard about a small-loan program and borrowed $40. She spent $35 on a small shack outside the camp, and the remaining $5 on vegetables, which she resold. Turning a daily profit of $2.40, she managed to tuck away 40 cents a day. Within six months Hernandez repaid her original loan and took out a second loan for $48, which she used to purchase a pig and a chicken. Today she's enrolled in a literacy class and her children all attend school.

By having access to credit, Grundy says, people like Hernandez begin to feel self-esteem. They gain a sense of control over their lives and they begin to identify with capitalism—because, for the first time, they're benefitting from it. "People need to have a stake in the system. When they do have a stake, they feel empowered," he says.

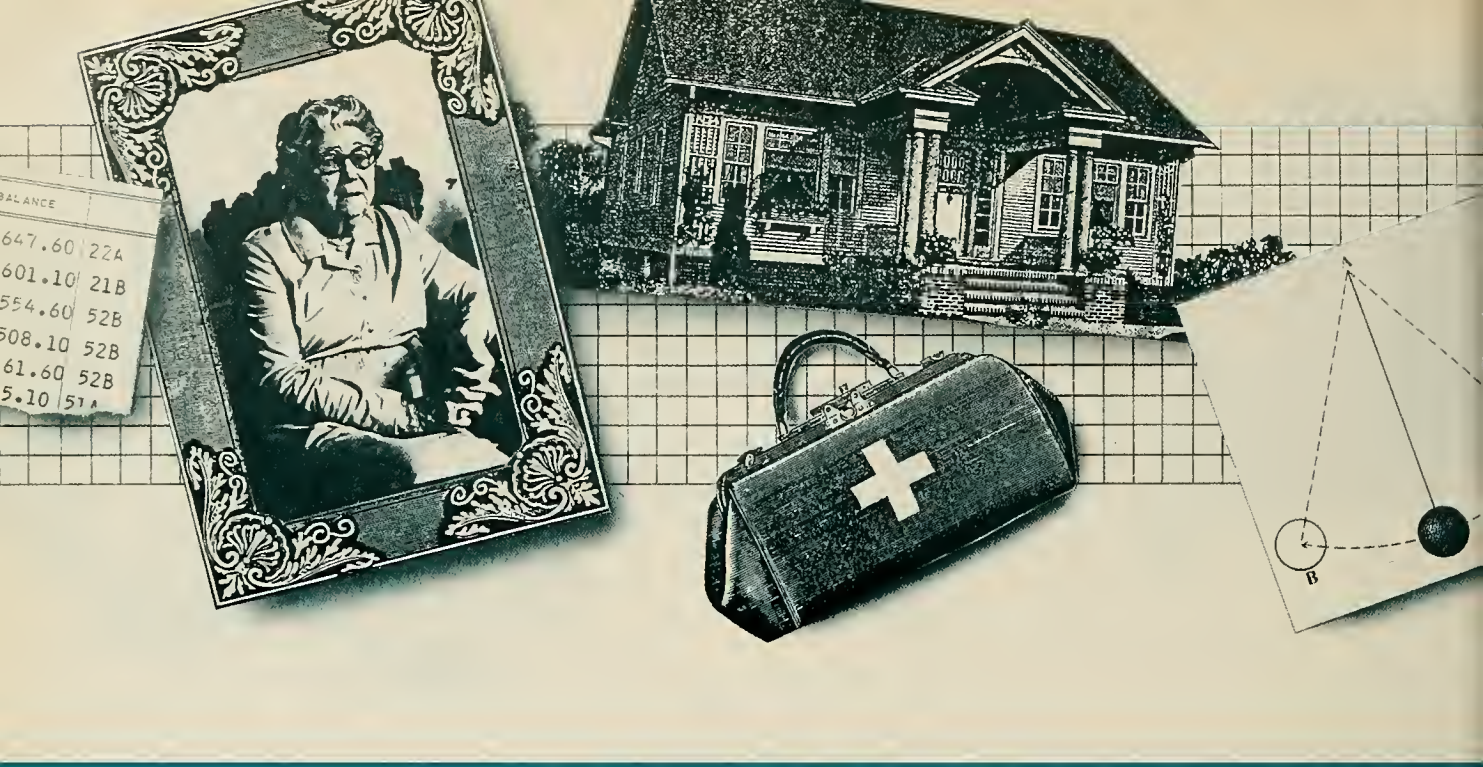


Kenneth Grundy

The repayment rate for small loans in Bangladesh, Peru, and Indonesia is higher than 95 percent—much better than the 65 percent rate for Third World banks that lend to larger firms, Grundy points out. Moreover, the ledgers show that the poorer the borrower, the better the payback rate. Since the loans are so small, entrepreneurs like Hernandez can pay one back quickly and then take out another, so the capital keeps circulating.

In the 1987 Foreign Aid Authorization Act, Congress earmarked a small portion specifically for micro-enterprises. At least $50 million in fiscal 1987 and $75 million in fiscal 1989 were to be used for small business loans of less than $300, extended at prevailing market rates. Grundy is heartened by the law, but he points out that the amount targeted at micro-enterprises is just 3 percent of the total $6 billion budget for non-military aid.

"There are tremendous success stories," says Grundy. "People's lives are being changed in very positive ways. Of course, they're not the kind of success stories you'll hear about on the nightly news; micro-enterprise won't change the economy of Bangladesh overnight. Patience is the watchword when you do things on a small scale."



CARING FOR THE AGED: *There's no place like home*

The "graying of America" will begin during the next decade and peak around 2030, when today's Baby Boomers — one-third of the current U.S. population—will be senior citizens. Providing services so that the elderly will be able to continue living on their own should be a top priority, says Julia Paparella, associate professor emeritus of nursing at Villanova University.

lia Paparella

"I don't think we have enough emphasis on trying to keep elderly people in their homes," says Paparella, who is president of the Board of Family Service for Montgomery County, Pennsylvania. "There are definite advantages to living in familiar surroundings. The elderly know where they are," she says, and they "cherish the memories" attached to the homes in which they may have spent their entire adult lives. She points as an example to her independent 91-year-old mother-in-law who lives alone—except for a paid companion who comes in each weekday from 9 until 5.

Some seniors undoubtedly require the medical care and round-the-clock supervision best provided by hospitals and nursing homes. But as life expectancy continues to increase—and people live to be "old" for a longer period of their lives—there will be a gap between the time when the elderly first need minimal help and the time they require full-blown hospitalization.

Home care during this period, says Paparella, is far preferable to nursing home care, particularly in the face of the predicted nursing home crunch. To meet the demands of just the next decade (long before the Baby Boomers will be ready to book rooms), 220 new nursing home beds must be added every day.

Moreover, the economic costs of long-term nursing home care can be tremendously draining, even for the well-heeled, says Paparella. The average nursing home costs $23,000 for a year's stay, and some charge more than $60,000. These figures promise to jump once the predicted shortage begins. Medicare and many private health plans generally won't cover the cost, and Medicaid will only chip in after a nursing home resident has depleted his or her savings and other resources.

Many seniors could avoid such hardship, Paparella believes, through a combination of government funding, community volunteerism, and restructured health care policy. First off, she would like to see doctors begin paying "house calls" again, as they did earlier in the century. "Many elderly people just aren't capable of getting up and getting out" for regular check-ups, she says. Increased funding for community nursing services, she adds, would enable more people to benefit from in-home visits paid by physical and speech therapists and nurses.

Even for those who are active enough to get to the doctor's office, driving a car isn't always practical. That's where volunteers can serve as chauffeurs or otherwise help out by making regular runs to the grocery or drugstore. Paparella notes the success of the Meals-on-Wheels program, which delivers hot food to the homebound elderly. She believes a similarly structured program could provide homemaking services for seniors who can't keep up with the vacuuming, dusting, and laundry.

Respite care is another vital service that needs to be bolstered, according to Paparella. Currently, 2.5 million people are debilitated by Alzheimer's disease; that number is expected to reach as high as 7 million by 2040. Alzheimer's patients in particular often require non-stop attention from the spouses or children who opt to care for them at home. The respite care program brings paid staffers or volunteers in to relieve family members for a few hours.

"It gives the caregivers something to look forward to—something different to focus on," Paparella says. "After a lunch out with a friend or an afternoon of shopping, they come back refreshed and can give better care."

CHEMICAL RISKS: *Assessing the hazards we eat and breathe*

Few diet soda drinkers can forget the brouhaha that bubbled up early in the late '70s when policy makers tried to determine whether saccharin causes bladder cancer in humans. When the results were in, the findings were far from conclusive, recalls Robert Rubin, an environmental toxicologist at Johns Hopkins School of Hygiene and Public Health. Some analysts contended that you'd have to drink 600 cans of diet soda a day to develop bladder cancer—or that your odds are essentially one in a billion. More conservative analysts said that at just one can a day, your chances are one in 3,000.

As we head into the '90s, uncertainty continues to rule the day in the field of risk assessment, says Rubin, whose work focuses on determining what fraction of the population is at risk of developing a disease after being exposed to a particular chemical. "The uncertainty in risk assessment can be enormous—for many chemicals it's in the range of a million-fold difference," Rubin says.

The enormous disparity makes life difficult for government regulators—known as "risk managers"—who must decide what to do about a particular hazard once scientists have identified it. Generally, says Rubin, federal officials will act conservatively, heeding the evidence indicating highest risk. "After all, who wants to be known 20 years from now as the person who allowed hundreds of thousands of people to be exposed to cancer?" he asks.

The public's *perception* of a particular hazard plays an important role in shaping policy, Rubin notes. Often, the risks that stir the most outrage are not the most deadly. People are more willing to accept voluntary risks than ones they feel are out of their control. And they're more concerned by risks that could cause large numbers of injuries or deaths at one time. Thus, they feel safer getting behind the wheel of a car than they do relinquishing control to the pilot of a 747, even though far more people die each year on American highways than in well-publicized airplane crashes. Man-made hazards seem to be less acceptable than natural ones; hence, people balk at living near nuclear power plants or toxic waste dumps, but are willing to make their homes in earthquake-prone California.

In the case of saccharin, consumers felt that the benefits of having sugar-free, low-calorie food products outweighed the potential risk of bladder cancer, Rubin says. When the Food and Drug Administration (FDA) proposed its ban on the artificial sweetener, the "public hue and cry" was so persuasive, Rubin says, that President Jimmy Carter put a moratorium on the ban.

Robert Rubin

Twenty years ago "risk assessment" was virtually unheard of, Rubin says. Today we're a society awash in chemicals. We eat them, drink them, breathe them. The field of risk assessment emerged in the last decade as technological advances have enabled scientists to detect whether specific chemicals are harmful and to examine how the body reacts to chemical exposure.

It doesn't take a crystal ball to predict which chemicals will come under the closest scrutiny during the '90s, according to Rubin. Topping the list are chlorinated hydrocarbons (found in a variety of pesticides and produced when drinking water is chlorinated). Trichloroethylene, for example, widely used as an industrial solvent, ends up in our water supply when not disposed of properly.

The list of potentially hazardous chemicals promises to grow, Rubin says, thanks to ongoing advances in detection. "With the passage of time, our analytical instrumentation will become increasingly more sensitive and sophisticated, so that 10 years from now, we'll be able to measure risky dosages at lower and lower levels."

Reducing the uncertainty in risk assessment—coming to a consensus about the actual risk that chemicals pose—will be a major thrust for chemists and molecular biologists in the years ahead.

ARTIFICIAL INTELLIGENCE: *Closing gaps between mind and machine*

David Brown specializes in artificial intelligence (AI)—programming computers with knowledge and reasoning ability so that they can "think" in the same manner humans do. "The aim of artificial intelligence should be to understand the steps that go into doing complicated things," explains the associate professor of computer science at Worcester Polytechnic Institute. "What does it mean to understand a scene, for example, or to understand a medical diagnosis?"

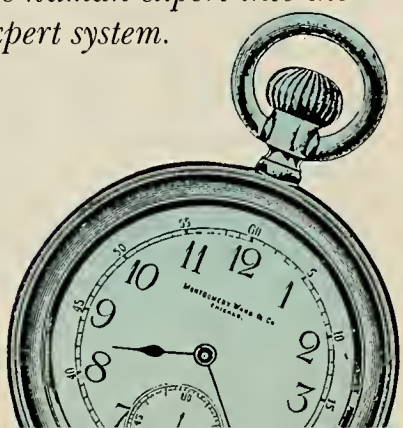
The challenge ahead, he says, lies in knowledge acquisition—"finding better ways of getting knowledge from the human expert into the computerized system."

Brown is particularly interested in recreating the human process of design. "If you try to simulate intelligent behavior, the only way to do it is by tackling real problems," he explains. "You need to get your hands dirty and try to understand it. Design and manufacturing is a good place to do that."

The concept seems simple enough. Brown starts by analyzing the problem a manufacturing firm might face. In one instance, a maker of air cylinders—which enable components to move backward and forward reliably—needed to redesign its product for each new customer to account for varying space, temperature, and pressure requirements. Brown interviewed an air cylinder designer, then developed a computer language that was capable of representing what the designer knew.

The language is task-based, he explains, and consists of sequential steps. Each step obtains required information, makes calculations, and then comes to a decision about a particular "attribute"—such as how wide the cylinder's piston must be. Brown used the language to create a program through which the computer could design each air cylinder.

The challenge ahead in computer intelligence lies in knowledge acquisition—finding better ways of getting knowledge from the human expert into the expert system.



Unfortunately, analyzing what people know and how they use what they know is an extremely complex task, says Brown. When humans solve problems, they often go through thought processes so subtle that they aren't even aware the processes took place. That makes it difficult—if not impossible—for them to articulate their reasoning to the inquiring computer scientist.

David Brown

Moreover, says Brown, humans integrate knowledge from a variety of sources, and they make decisions based on individualized situations. These factors must be taken into consideration when trying to program an expert system to decide.

Another important area of knowledge acquisition involves "learning from experience," Brown explains. When performing a new task or solving a new problem, we often look to past mistakes and successes, or we analogize from a past experience. Devising a database with this kind of comprehensive information is difficult, Brown concedes, but the experiential thought process is important when designing expert systems.

"What we are realizing in AI," says Brown, "is that there is no one thing called learning, but instead many things, put together, which constitute learning behavior."

OVERCROWDED PRISONS: *Finding our way out of the warehouse*

"What we are seeing in our jails and prisons are people who come from nothing, to get nothing, who leave with nothing, to return to nothing," says James J. McKenna, Jr. "And then we wonder why our prisons don't work and our criminal justice system isn't more effective."

The United States must end its "over-reliance" on prisons as the first choice for punishment and rehabilitation, argues the director of Villanova University's criminal justice and human organization science programs. Currently, prisons in all but 10 states are overcrowded (some to 150 percent of their intended capacity). That makes it extremely difficult for prison officials to provide a secure living environment, let alone any meaningful rehabilitation, McKenna says. Society ultimately pays the price exacted by such "warehousing," he notes, since 95 percent of those doing time will at some point find themselves back out on the street—frustrated, angry, and jobless.

At Philadelphia's Holmesburg Prison, for example, guards spend much of their time shepherding inmates to and from meals. The swollen population means that breakfast extends from 7 a.m. to noon, lunch from noon to 5 p.m., and dinner from 5 to 10 p.m. Imprisonment is inherently stressful, says the three-term president of the Pennsylvania Prison Society, a non-profit prison watchdog group. Inmates are held against their will in cells the size of walk-in closets.

"If you have an environment where stress is normal, and you increase that stress by overcrowding, you then have serious potential for physical and sexual violence," he says. The three-day riot last October at Harrisburg's State Correctional Institution at Camp Hill—which was operating at 145 percent capacity—is just the latest example of what can happen when such tension reaches the breaking point. By the time the smoke cleared at the Pennsylvania prison, 74 inmates and correctional officers had been injured, and $15 million worth of buildings had been destroyed.

"The immediate solution to overcrowding has been to build our way out of the problem," McKenna says. "To me, that is shortsighted. We just can't afford the price of building more prisons—the economic costs are out of sight." Constructing a single maximum security cell costs in excess of $75,000, he says.

How can we pare down our prison populations? McKenna offers a grab bag of suggestions, among them enacting tougher handgun control laws, decriminalizing drugs to reduce their profit, and developing mental health systems so that prisons aren't forced to handle the fallout when mental institutions release patients.

Jim McKenna

He also advocates reduced sentencing, parole for lifers, and furloughs. Patterned after work-release programs being used now in Europe, furloughs would enable offenders to spend their time working in factories rather than sitting in cells, he says. And preparing inmates to find employment once they leave jail, he adds, is crucial to preventing recidivism. In 1972, McKenna established a program at a maximum security prison that enables inmates to earn an associate of arts degree from Villanova.

McKenna estimates that half the inmates currently in Pennsylvania county jails are there awaiting trial because they couldn't make bail—either they're too poor or are considered too much of a threat. Noting that bail is intended to guarantee appearance at trial, not to serve as a punishment, McKenna contends that this pre-trial detention violates the individual's constitutional right to due process.

He stresses the importance of addressing the socioeconomic conditions that give rise to crime in the first place. "The ghetto youth of 14 or 15 is certainly going to be more attracted to making $300 a day pushing crack, rather than earning $3 an hour in a fast-food burger joint."

ILLUSTRATION: ROYCE FADDIS. PHOTOS COURTESY OF RONALD R. BOYCE, SEATTLE PACIFIC UNIVERSITY

FUTURE FLUX

It's the edges we perceive—between light and dark, the Wall and freedom, the old and the new.

BY ROBERT KANIGEL

Downtown, these days, too many tall buildings go up too fast. It's a sight to see, of course, the beams and girders rising day by day, cranes silhouetted against the sky, all raw energy and fresh promise. But it's also faintly disturbing: too fast, too much, too many. Who can keep up? Turn your back for a minute and they're clearing the site for another one, wiping away what was—buildings you knew, stores you once patronized. Somehow, the city is not quite yours anymore. Besides, they never ask your permission. *They* just go and do it.

Medical breakthroughs stir similar ambivalence. So do computers, as you gawk at the latest 324 TMx whirring and blipping through its paces: *Oh, what they can do these days.* Admiration, delight—yes. But also, if there's the barest breath of reactionary in you, some pang of misgiving. It's almost *too* wonderful, *too* much.

Change, ubiquitous though it is, is an abstraction. The new postmodernist office tower on the skyline isn't change; neither is the new cancer therapy. Change, rather, is a kind of subtractive process where you look at what was, then look at what is, and note the difference—the before and after snapshots compared.

Stick a hungry frog in a cage with a dead fly, it is said, and the frog will die of starvation because it doesn't see the fly; it sees its movement, its shifts in position. Though change is abstract, living things sense it. Say you're steering your car through a sharp turn, or accelerating up to highway speed. Your body's inertia resists the change in speed or direction—and your nervous system knows it. You have specialized cells in the visual cortex of your brain that respond not to light per se, nor to darkness, but to *edges*—the borders between light and dark that mark the passage of one into the other.

Living things *need* change. Some years ago, sensory deprivation chambers were a minor fad. You'd lie in a silent, dark, warm, womb-like chamber, all the chaos of the world kept scrupulously out—and after a while you'd start to hallucinate. If the environment doesn't supply any stimulation, it seems, your nervous system manufactures its own. Or take the child bored on a Sunday afternoon.

"Go read," says Dad.

"I did that," says the child.

"Go play with your toys."

"I'm tired of playing with them."

The kid wants *something new*. An art critic once noted that no one could truly appreciate a painting for more than two minutes; however sublimely beautiful, the painting soon loses its freshness to your eye. Likewise, the smell of fresh ground coffee in a San Francisco coffee house is mostly lost on you after an hour or so; it's the onset of the aroma, not its persistence, that you notice.

People must change, else stagnate. The same goes for industries, academic disciplines, whole societies. "God forbid we should ever be 20 years without . . . a rebellion," wrote Thomas Jefferson. The sociologist of science Thomas Kuhn

has shown how scientific fields undergo revolutions much as societies do. At the turn of the century, for example, many believed that classical physics had all the answers, that no more big problems remained to be solved. Then came the Revolution—the intellectual bullets and barricades of Einstein's relativity theory.

It took a while, of course, for relativity to be accepted. After all, most new and original ideas, theories, buildings, and products are indeed new and original, but not always better; perhaps it isn't surprising, then, that people resist the pull of the new. But whether beneficial or not, change always threatens someone, always makes for winners and losers. When Watson and Crick discovered the structure of DNA and ushered in molecular biology, practitioners of the old biology saw their work seem suddenly irrelevant. If cold fusion had successfully launched a new age of cheap energy (and it becomes daily more apparent that it has not), what might have been the fate of coal miners in West Virginia, oil field hands in Texas, or tokamak researchers in Princeton? And what of old-line Communists in Leipzig or Prague? Some of them today are unhappy indeed, even as the rest of the world hails the happily bloodless revolution that deposed them.

"If the environment doesn't supply the stimulation, it seems, your nervous system manufactures its own."

Sudden change means that you're no longer quite so at home in your world. If *National Geographic* went, overnight, from its yellow-bordered covers to some snappy chartreuse, you might, in the end, welcome the change, or you might not. But at first, certainly, some part of you would grieve to see that cultural icon swept away.

First-year calculus students step into a world of "delta x" and "delta y"; the deltas mean change.

Newton, one of the inventors of differential calculus, called it "fluxions," the mathematics of flux. Calculus asks how fast one thing changes with respect to another. Velocity, for example, is how fast position changes with respect to time. Mathematically, velocity is a "first derivative"; the *second* derivative measures how fast the *first* derivative changes, and gives the rate-of-change of change.

It was 20 years ago today, more or less, that Alvin Toffler wrote *Future Shock*. It was not merely that we live in a changing society, he said, but that change was accelerating; society's second derivative was climbing. It was The Death of Permanence, he said. It was the era of The Accelerative Thrust. Toffler had much to say about the kinds of changes he saw in America. But "future shock" had less to do with the direction of change than with its pace.

The faster change comes, the faster we must adapt to it, and that takes its toll. This was among Toffler's key points: that you have only so much "adaptive energy." Change exacts a price on the body in the form of stress. And too much, too fast—whatever its benefits—wears you out, even makes you sick.

This, you could say, was part of what went wrong in the 1960s. The times, you may recall, were a-changin'. But that they were changing wasn't the problem, or at least not the only problem; it was that they were changing so fast. For a tumultuous few years it seemed that if something had always been done one way, that was reason enough now to do it some other way. Drugs, sex, sex roles, politics, music, etiquette, dress, hair, even, for heaven's sake, the typefaces used in underground newspapers and rock posters—all changed, overnight, all at once. And many people—even many on the crest of the wave—felt swamped. All their pat assumptions about the way things ought to be were overturned like a restaurant table by a boisterous drunk.

So it's possible to applaud a change, yet be dismayed by its abruptness. When the East Bloc countries began to quiver with freedom, the world reacted with almost universal joy and optimism. But recently, as the changes there have speeded up, gone headlong, we heard the first whispers of caution—the specter of an "unstable," potentially more dangerous Europe. Remember when *liberté, égalité, fraternité* swept France? Remember Madame Guillotine? (Remember Romania?)

Or take "changing neighborhoods," a euphemism for once lily-white blocks turning increasingly black. Critics said "change" was a code word for racism, which often it was. But in some instances, racial integration might have been better accepted had its pace, while inexorable, been something short of panic-driven, with half the houses on a block bearing FOR SALE signs at once. The problem wasn't entirely that these neighborhoods were changing, nor even necessarily that they were changing for the worse, but that they were changing so fast.

Is there some non-Newtonian Law of Motion that demands change—but not too much of it? Perhaps some physical constant, as immutable as pi, that describes the degree of change we can comfortably endure?

The times that stand out in memory are usually those most awash with change. The new job or the new baby, the beginning of a love affair, the reports from Utah about cold fusion, the news last fall from Prague and Warsaw. Heady times, with so much that's new and unpredictable, and sometimes terribly frightening, or sometimes so thrilling you can hardly stand it. Change hurts, troubles, inconveniences—but you die inside without it.

Imagine an America in the year 2090 that is just like America today. No sci-fi time warp here: Ordinary people still live and die, still grasp for money, power, and love. Years on the calendar still slip by. But unlike our times, the background details in 2090 all stay the same, unchanging, like pre-industrial societies, where the slightest innovation took a hundred years to filter through. So now, in 2090, we have the same computers as we did in 1990, the same do-everything touch-tone telephones. The Democrats and Republicans still yammer away. There are no new religions, constitutional amendments, art trends, or scientific breakthroughs. Acid rain, the greenhouse effect, and teenage mothers are still major issues. The crime rate remains constant. Abortion still divides the country. Women still wear shoulder pads. The same Nut 'N Honey commercials are shown on TV, the same Toyota Tercels and Buick Rivieras fill the same suburban parking lots. The city skyline remains just as it did in 1990.

An unlikely vision? Mercifully.

Robert Kanigel is a Baltimore writer who most recently wrote for the Alumni Magazine Consortium about foreign language learning. He's currently writing a biography about Ramanujan, the Indian mathematical prodigy.

"It Was a Wild Night All Around"

Mike Briere '84 had a front-row seat to watch the Berlin Wall come tumbling down.

November 9, 1989, began routinely for Michael Briere '84, a guest scientist at the Hahn Meitner Institute in Berlin, West Germany.

Briere lives in Steinstuecken, an enclave of the city that is virtually surrounded by the Berlin Wall. Before heading off to work on that about-to-be-momentous Thursday, he glanced out his living room window at the high concrete barrier that cuts through his backyard. The East German guards were there, as they always were, watching from a tower atop the wall.

Briere says he'd become accustomed to living in the shadow of this famous structure and to traveling the one road out of Steinstuecken into Berlin, a road bordered on both sides by the wall.

On that late fall day, West Berliners were becoming used to the idea of change on the other side of the wall. Already several Soviet bloc nations were permitting East German citizens to emigrate. Three months earlier, it had been reported that the East German border guards had received a stern directive: "No more shooting to kill." While their neighbor had become "a kinder, gentler DDR," Briere says, East Germans still seemed a long way from freedom. So, what happened that evening was surprising indeed.

At 8 p.m. the East Germans announced that the wall was about to open. Although he could still see armed guards watching from the towers, Briere proceeded to the east-west crossing near Checkpoint Charlie, the gate made famous in countless spy novels. He could see thousands of others waiting near the equally famous Brandenburg Gate.

About 11 p.m. Briere joined a German friend who owns a bar near the wall. Like many West Germans, the friend thought the announcement was a hoax, but within the hour hundreds of thousands of East Berliners were freely passing through the gates without the need of visas. "There was a lot of activity and excitement," Briere says. "West Berlin was wall-to-wall with people.

Cracks in the wall: Mike Briere uses a chisel to retrieve a bit of history.

"Once in West Berlin, the East Berliners filled their roomy plastic shopping bags with fresh fruits and vegetables and Walkman radios, real rarities in the East," Briere reports. "Each visitor was given 100 marks as welcome money by the West German government."

Some window-shopped for new cars, especially the VW Golf, which they consider a great improvement over the smog-producing, sluggish two-cylinder models on sale in the East. After a while it got cold and everyone looked for a place to sleep. "Many spent the night on the floors of banks and even in the aisles at McDonald's," he says.

Everything happened so suddenly it took some getting used to. Just a week earlier people in East Germany had been afraid to speak their minds, even in their own homes, for fear of reprisal. Now they could say anything, anywhere. Some of the refugees who had come to the West through satellite countries just before the wall opened talked about returning for their children, whom they'd virtually abandoned during their flight.

"It was a wild night all around," Briere says. "People were climbing on top of the wall and chipping it with chisels." Many, Briere notes, neglected to wear goggles or helmets and hurt their eyes and heads with flying stone chips.

Commercialism ran rampant. Hucksters sold chips from the wall as fast as they could bag them. T-shirts with messages were big sellers. One said simply, with a nod to Batman, "Gorbachevman, danke." The most popular read, "The last one out turns off the lights!"

Although the newly established east-west gates in the Berlin Wall have remained open since November, including the Potsdam Bridge gate through which U-2 pilot Gary Powers walked to freedom in the Eisenhower days, the East Germans have not totally relinquished control of the world-famous barrier.

In some places near Briere's home, holes were opened during the revelry. Soon after, work crews from the East arrived to quietly attend to the task of patching them up.

—Ruth Trask

EUROPE CLEARS THE WAY FOR 1992

IN JUST TWO YEARS many of the hurdles that have stood in the way of a true European Common Market are set to fall. The result will be the creation of the world's largest global trading bloc, one with the combined population of the U.S. and Japan. What will life and business be like after Europe 1992?

BY
BONNIE GELBWASSER
AND
RUTH TRASK

In 1992 the world will observe the 500th anniversary of the voyage of Christopher Columbus. His discovery of the Americas was the first step on the road to the creation of the United States, which is now in a race with Japan for the title of the world's greatest economic power. Perhaps coincidentally, 1992 is also the target date for the formation of a truly common market in Europe, a move that will unite 12 European nations into an economic giant whose might will rival that of the U.S. and Japan.

The road to a united Europe has been a long one. The process began in the aftermath of World War II and reached its first great milestone in 1951 with the Coal and Steel Community Treaty of Paris. That agreement was, in part, a move to promote the reconciliation of France and Germany and to help integrate the new Federal Republic of Germany into Western Europe.

With the signing of the Treaty of Rome in 1957, the European Community (EC) and the Common Market were born. The EC originally consisted of six members: Belgium, France, Italy, Luxembourg, the Netherlands and West Germany. The level of cooperation among the members was significant but limited, consisting mainly of the removal of tariffs and quotas on trade.

Since then, with the addition of Denmark, England, Greece, Ireland, Portugal and Spain, the EC has grown to 12 members. The community has also put behind it a long period of conflict and rallied around an increasingly vital goal—making Europe better able to compete with the U.S., Japan and the other rising economic powers in Asia.

In 1985, the EC nations agreed to a White Paper that advocated the elimination of a multitude of trade barriers (such as border restrictions and tax laws) that were eating into profits for European firms—profits that might otherwise have gone into research, development and growth. Clearly, to make Europe a force to reckon with, the barriers had to fall.

Out of the White Paper came the Single European Act, which outlined 300 areas for action with a deadline for a unified Europe of December 31, 1992. By mid-1989, about half of the obstacles had been removed or were well on their way to acceptance.

Among the most important changes that will be brought about by what Europeans refer to simply as "1992" are the reduction of border controls and the costs of cross-border shipments, the reduction of restrictions on road transportation, the mutual recognition of professional qualifications, and the elimination of restrictions on the movement of capital between EC countries.

Inevitably, 1992 has raised questions within the EC and, especially, in countries on the outside of the community. How will lowering trade barriers improve life for companies within the EC? Will smaller companies suffer as larger firms engage in mergers, acquisitions and takeovers to increase their competition in this huge market? Will foreign firms benefit by having freer access to the 320 million consumers in a unified Europe, or will they face increased protectionism and restrictions—a veritable "Fortress Europe?" Will the decline of communism in Eastern Europe slow progress toward the goals of 1992 as Europe gets bogged down in aiding East Germany and other Warsaw Pact nations?

To get answers to these questions, the *WPI Journal* talked with seven alumni who live and work in Europe.

ILLUSTRATIONS BY MICHAEL HILL

JOHN R. LEWIS '65

Managing Director, IDAC Automobillacke GmbH + Co. KG
Bonn, West Germany

A native of Attleboro, Mass., Lewis moved to Europe in 1988 to join IDAC, a joint venture that combines the European automobile paint businesses of Imperial Chemical Industries in Great Britain and E.I. du Pont in the U.S. The company sells paint to automotive companies throughout Europe, including BMW, VW, Peugeot/Citroen, Ford, General Motors/Opel and Volvo, and operates businesses in five EC nations.

Lewis thinks the companies most likely to succeed in the new Europe will be those that can "think and act European, rather than nationalistic. They will establish personnel policies that promote people on the basis of ability, not nationality, and have policies that enable easy relocation of people to help promote personnel development and assure that a company has the right person in the right place at the right time.

"While successful European firms will sell in France in the language, manner and customs preferred by the French, in Germany as preferred by the Germans, and so on," he adds, "they will locate production, research and development, and headquarters where they make economic sense. They will also keep an eye on North America and Japan to ensure that they are offering world-class products and services."

The approach of IDAC is an example of this strategy, Lewis says. "Ford and General Motors operate assembly plants in Belgium, Germany, Spain and the United Kingdom. Each plant, in theory, requires similar paint products. In practice, though, each needs specific products suitable to local conditions and accompanied by technical sales service people who speak the local language and know the local customs."

While most people anticipate a period of growth and overall prosperity in Europe after 1992, Lewis says many industry leaders also worry that not everyone will be better off in a more cooperative Europe. Stiffer competition could lead to isolated problems—perhaps the

closing of a steel mill here or an automobile assembly plant there—which could put thousands out of work. "In Europe, where a social conscience translates quickly into political action, sharp changes in employment patterns could lead to upheaval in governments and bring about restrictive legislation."

Lewis believes that the growing openness in Eastern Europe can help speed the transition to a more united EC by providing new markets for businesses in Western Europe; this should help less competitive companies stay afloat. That, in turn, could ease the political pressures that might otherwise hamper the continuing development of the EC.

"IDAC views the developments in Eastern Europe very positively," he says. "We currently sell products in Poland, Czechoslovakia and Yugoslavia. Improvements in the Eastern European economies will ultimately represent opportunities for our customers there. If IDAC serves those customers well, that will translate into more business for us."

—Bonnie Gelbwasser

Claude P. Mancel '71 (M.S.)

Vice President for Research and Development in Europe
Procter & Gamble
Strombeek-Bever, Belgium

Mancel says small European companies will most certainly be at risk after 1992 unless they can offer a unique technology or market a unique line of products. Already, he says, many small companies that don't have the research and development money they need to remain competitive at the European level have entered into mergers with larger European and international firms.

Between 1987 and 1988, he says, there were more than 100 transnational mergers in Europe. Each, he adds, has further weakened the position of small companies that choose to remain independent.

The consolidation of European businesses will also make it more difficult for non-EC companies to compete in Europe, unless they already have a sizable European presence, says Mancel, who earned his master's and doctoral degrees in chemical engineering at WPI.

"Companies such as Ford and Procter & Gamble," he says, "which have well-established local structures in Europe, backed up by strong business around the world, are as well equipped as European companies to profit after 1992 because of their understanding of European regulations."

Over the last four years, Mancel says, Procter & Gamble has increased its European presence with the acquisition of, among other firms, Richardson-Vicks, a health and beauty aid company with strong European brands; Blendax, a company selling the leading toothpaste and bath additive in Germany; and Nelsen, an Italian household detergent. It's quite possible, he says, that none of these acquisitions would have been possible if P&G were not already operating in Europe.

While most Europeans welcome the idea of a single market, believes Mancel, there are varying opinions about the best way to achieve European unity. These differences, he says, stem from uncertainty over how a more unified Europe will affect individual European nations and individual Europeans. Belgium has expressed strong support for the spirit of 1992. "This is not surprising," he explains, "considering that Belgium is the second largest net exporter in Europe. It is already implementing most of the principles of a unified market and, as a result, is the most likely country to benefit."

Brussels, where the European Commission (the community's executive body) resides, considers itself the capital of Europe and hosts a large community of foreign diplomats and Eurocrats (administrators for the Common Market). "The U.S., for example, already has three ambassadors in Belgium—one for Belgium, one for the EC, and one for NATO."

While Mancel says the jury is still out on how changes in Eastern Europe might affect the unification of the Common Market, he says a more open Eastern Europe will represent both an opportunity and a challenge to the EC. On the one hand, Eastern Europe is a huge new market that is now within reach. At the same time, though, the changes, as well as concern about the economic impact a unified Germany will have on the EC, could put a strain on a not-yet-consolidated European Community.

—Ruth Trask

"In the long term, companies that do the best job at achieving customer satisfaction will prosper."

Marc E. Schweig '70

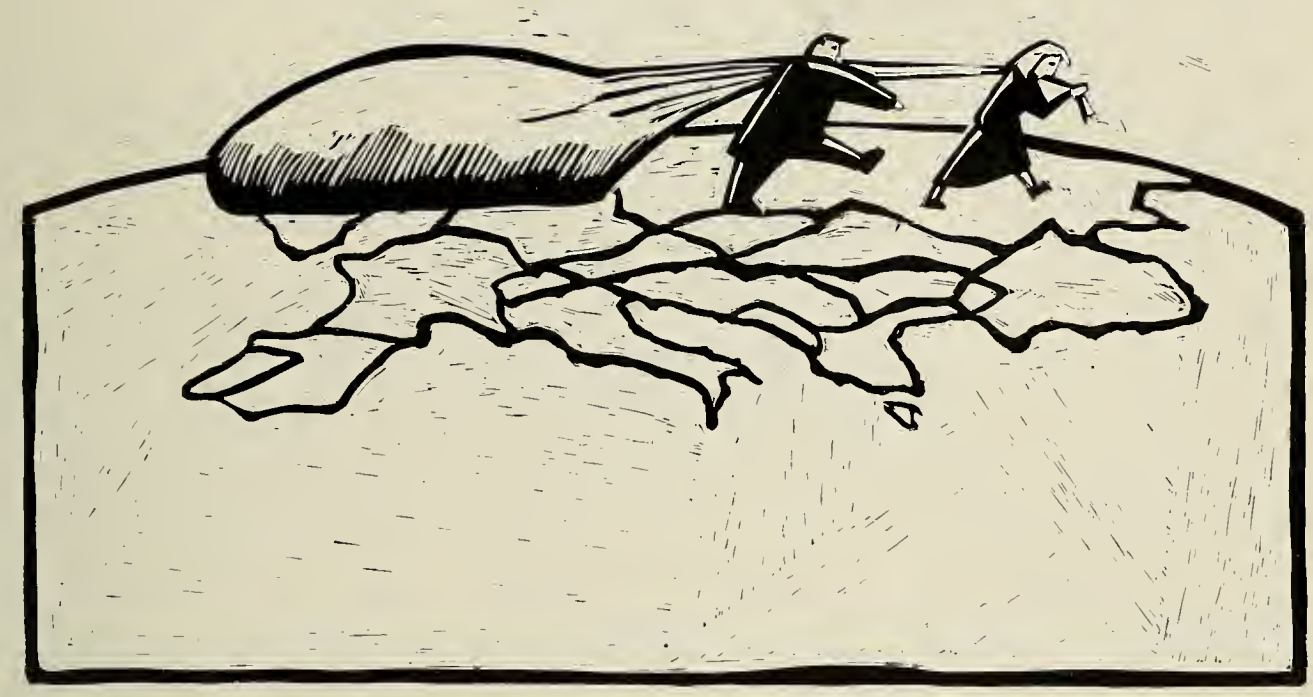
Director of Product Management, AT&T Network Systems International (NSI)
Hilversum, the Netherlands

How will the changes planned for 1992 affect businesses in Europe? Schweig, a Boston native who now works in AT&T's European headquarters in the Netherlands, says many commercial and industrial firms will find it necessary to get bigger, thus increasing their economies of scale, in order to stay competitive. "This has been happening in Europe for many years, especially among firms involved with the movement and management of information," he notes.

"In the long term, companies that do the best job at achieving customer satisfaction will prosper," he adds. "Companies at the greatest risk are medium-sized businesses that have aspirations of pan-European growth, but aren't competitive or don't have the financial resources."

Schweig says he doesn't think people in the Netherlands will see any major changes in their everyday lives as a direct result of 1992. Most of the changes, he says, will be gradual, such as the emergence of truly European broadcast networks and changes in the mix and mobility of the European work force. "Increased competition will lead to lower prices for air travel. Increased transborder shopping will ultimately place pressures on the widely divergent tax structures of many countries."

Those same pressures, Schweig says, may ultimately bring to fruition one long-term goal of the EC—the adoption of a common European currency. While the European Monetary System was established in 1978 to bring stability to ex-



change rates in Europe, a proposal to adopt a European Currency Unit (ECU) as a regionwide monetary unit has been accepted less warmly. As commercial codes become more uniform and trade between EC nations becomes easier, Schweig believes, businesses will prefer to trade in ECUs.

"In addition," he says, "the emergence of intra-European banking [another pending proposal] will put more pressure on federalizing currency."

Contrary to the more pessimistic view taken by many in Europe, Schweig believes the reforms sweeping Eastern Europe will likely strengthen the European Community. In the short term, the Eastern Bloc will be a fertile territory for exports from EC nations; in the longer term, East and West may align to form an entity with a collective economic might greater than that of either the U.S. or Japan.

The main cause for concern, he says, is that the Warsaw Pact countries could achieve "a new kind of unification of their own and penetrate the Western European markets on the basis of their low (relative to the countries of Western Europe) labor costs."

—Bonnie Gelbwasser

Henry M. Strage '54

Director,
McKinsey & Company Inc.
London, England

Strage, a Belgian-born chemical engineer, prefers to think of 1992 as an ongoing process, rather than a set of changes that will occur in a single year. Acknowledging the more than 30 years of history that will have led up to that target year, he says 1992 will be yet another important step toward cooperation among the EC nations. "A lot has already been done just by normal processes," he notes.

In 1958, just after the creation of the European Economic Community, he says, imports and exports among EC countries represented 35 percent of their overall trade. Today that figure is about 60 percent. The goals of 1992 should increase that percentage still more.

McKinsey & Company, an international management consulting firm, has set up a Eurocenter in Brussels, Belgium, with a 50-member staff dedicated to helping European companies capitalize on the transition.

Some changes—for example the streamlining of border restrictions—could have a major impact on Common Market companies. "If you run a distribution network," Strage says, "it matters greatly that the virtual disappearance of red tape will allow your trucks to move at an average speed more than three times faster than they can today."

While some members of the EC have embraced the concept of 1992, Britain's prime minister Margaret Thatcher has been less than enthusiastic about certain initiatives and trends. Does Strage think she wants Britain to drop out of the EC?

"Not for a minute," he says. "She simply wants each country to maintain its sovereignty. And she feels that if Europe becomes too 'common,' we'll all lose our identity." Strage agrees with Thatcher's contention that Europe must first learn to live with the proposals now pending before any more major shifts are introduced.

Some changes, Strage says, should be easy to live with. "We'll have a much bigger market than we do today. About a 5 percent increase in gross national

"Today in the Fortune *500 list of the largest companies, European firms are not well represented," says Strage. "That is about to change."*

product is a conservative estimate. This represents a $260 billion increase in demand for goods and services."

Buoyed by their increased economic muscle, European companies will become more aggressive and competitive, he adds. The typical European company will get bigger as it expands and swallows up smaller competitors.

"Today in the *Fortune 500* list of the largest companies, European firms are not well represented," says Strage. "That is about to change."

Membership in the EC alliance will have another important benefit: a more competitive stance in the world marketplace. While Strage does not believe a Fortress Europe mentality will sweep the region in 1992, he says, "Europe will not be going out of its way to let American and foreign companies grow at its expense, should the economy have setbacks."

—Ruth Trask

Paolo G. Rambelli '80

European Patent Attorney,
Jacobacci-Casetta & Perani
Torino, Italy

At the moment, Rambelli says, there is no such thing as a unified European mentality in industry or business. Each of the 12 Common Market countries conducts business in its own way. "Nothing that happens in 1992 will change that," he contends.

Still, he says, the changes brewing in the EC will affect many companies in Europe, especially utilities and public service firms—banks and insurance companies, for example. "Up until now," he says, "they have been faced only with domestic competition."

In order to survive, such companies must become competitive with their counterparts in other EC nations, especially those in Germany, the EC's strongest member.

Rambelli believes companies that provide professional services, including his own law firm, will fare better. "We provide consulting services that have a high professional content and we don't expect more competition from firms already established in Europe or from newcomers."

Rambelli's specialty is patent law and he has been particularly interested in how the alliance of the 12 members of the European Economic Community will alter the patent process in Europe. A significant step toward a more unified approach to patent law was taken in 1978 when the European Patent Convention was established.

While there are still some differences to be worked out, the convention will make it possible for successful applicants to receive a "bundle" of national patents that have effect in each of the European Convention contracting states. Further changes could follow in the period following 1992.

Currently, Rambelli says, the European Commission is discussing directives concerning the patentability of developments in biotechnology. If approved, the directives will be binding on national courts throughout the EC. This should be an important development for an industry that depends heavily on patent protection.

While the march of progress continues toward 1992, Rambelli says there is fear among Italians that national interests may hamper the achievement of a completely unified Europe.

"The Italian situation in Europe is peculiar," Rambelli reports. "Whereas the skills of Italian entrepreneurs have turned Italy into one of the most industrialized countries, the inefficiency of our government has always been a heavy burden, against which Italian enterprises have had to fight. The fear is that those countries that can rely on high efficiency from their governments—Germany, for example—will prevail in Europe, and also in Italy."

—Ruth Trask

Hans P. Rufenacht '77

Head, Division of Studies and Design
Water Works of Geneva, Switzerland

Mati Weiderpass '81

Manager, Duty-free Sales
Swatch AG
Biel, Switzerland

As residents of a European nation that has chosen not to join the EC, Rufenacht and Weiderpass have unique perspectives on the approach of 1992.

"Switzerland won't be directly affected," Weiderpass says, "but there is constant pressure from the EC for us to comply with Common Market rules and regulations. In certain areas, such as standardization of manufacturing, medicine, import and export, and safety regulations, we're already in compliance. Such standardization is beneficial to Swiss consumers and to everyone else."

However, he adds, there are good reasons why Switzerland does not wish to join the EC. First and foremost, he notes, the country cherishes its neutrality and does not wish to be "too political" with its neighbors. Second, as a picturesque country right in the middle of Europe, Switzerland is a much-desired place of residence for citizens of neighboring countries.

"Under EC rules we would have no right to restrict our foreign population growth," he says. "This would be bad, indeed, for a small, mountainous country with little usable land. We simply can't afford to have many more permanent outside residents moving in. Already, Geneva's population is 30 percent foreign!"

Will Switzerland's businesses pay for their nation's insistence on neutrality? Rufenacht says most Swiss companies should have no trouble competing in a stronger Common Market.

"The bigger multinational companies, like Nestle, will be able to hold their own against competition from businesses in EC-member nations," he says. "They already have acquisitions throughout the European Community and worldwide that

For American Firms, It's Time to "Get on Those Bikes"

The changes on tap for 1992 will prove every bit as important to American companies as they will to European firms, observed Henry Strage '54 in a recent interview with ABC television. U.S. companies, he noted, have an enormous stake in anything that happens in the Common Market, which already accounts for 25 percent of the United States' exports and 40 percent of its foreign investment.

"For any American company that is, or plans to become, a global or international company, 1992 is crucial," he said. "It will have—indeed is already having—a profound impact on a whole range of industrial sectors."

It would be unthinkable, Strage says, for an American firm not to take seriously a single market with more than 300 million consumers, and most do seem to be getting ready. Many U.S. companies are already involved in European trade, with the larger ones operating in most EC countries.

"If there are American companies that haven't been looking to the future, they'd better get on their bikes soon, as we say in England," Strage cautions.

For those not yet on their bikes, is it too late? Have they lost any hope of taking advantage of the opportunities provided by a united Europe? Probably not, says Mati Weiderpass '81.

"Companies outside the EC won't be restricted too much," he says. "The whole idea of the EC is to open up trade worldwide. Perhaps U.S. companies should follow Japan's lead. Do you know that the Japanese are making cars in America and selling them back home in Japan?"

American companies that are already well-positioned within the European Community will undoubtedly have an edge over latecomers, notes Marc Schweig '70. But Schweig says there's still time for Johnny-come-latelies to get involved in "this huge marketplace."

To succeed, Schweig explains, companies "must first learn what the European customer wants—not what they want to sell to him. Second, they need to understand their European competition. Finally, they must appreciate the real motivation for a unified European market—to improve and strengthen European business on a global scale. This implies that *doing* business in the EC means *being* a business in the EC."

For those companies that remain outside the EC, 1992 will bring new restrictions, such as duties and limits, says John R. Lewis '65. In addition, firms that aren't represented in Europe will have a much harder time following the ever-changing European market requirements from the isolation of North America.

Getting a foothold in Europe is not an easy task, Lewis says. It is, in fact, "an expensive and time-consuming process. Acquisition candidates that are already European in character will be expensive, and the alternative of buying several small companies in several different countries and putting them together presents all sorts of challenges to the newcomer."

For successful American firms, participation in the European market can yield more than revenue, Lewis says. Europe is also a source of ideas, new technology and market trends. "The marketplace is rapidly becoming a world market with the same or very similar goods and services available in Tokyo, Frankfurt or Worcester. The issue will become, increasingly, 'Can American industry survive if it is only American?' "

What pitfalls should be on the minds of American firms interested in operating in Europe? "Language skills are a key tool most Americans lack," Lewis says. "It's difficult to be certain you understand your customer's needs if you can't talk to him." Basic social and political differences between the U.S. and most European nations may also hinder relations between the American and European business communities. "Extra sensitivity must be stressed in this area," Lewis says.

As an American citizen employed by an American company in Europe, Schweig says he is in a good position to gauge just how much anti-American sentiment is associated with the growth of the EC. "The answer," he says, "is 'less than one would think.' American products, technology and thinking are accepted in Europe today. IBM, DEC, HP, AT&T, Ford, Coca-Cola, Pepsi, McDonald's and Burger King are all household words. In the cinema, Europeans watch American movies; on TV, they watch 'Dallas.' If we have the right products, if we work like European companies, we will continue to succeed in this new market."

—Bonnie Gelbwasser and Ruth Trask

ILLUSTRATION BY ROYCE RADDIS

"Those companies that cannot replace their workers with cheaper labor elsewhere, in the Third World, for example, are slowly going out of business already."

will keep open the market for them."

The companies most at risk will be smaller firms that are already having difficulties due to Switzerland's high labor costs. "Those companies that cannot replace their workers with cheaper labor elsewhere, in the Third World for example, are slowly going out of business already."

Principally because of two key factors —its location (Switzerland is surrounded by the EC) and the country's distinct banking regulations—Switzerland will definitely undergo "intense changes" after 1992, Rufenacht predicts.

"Economically, Switzerland will move closer to Europe than it is now," he says. "The country is now considered an island with unique banking and tax legislation. In the long run it will have to assimilate with the surrounding countries."

Aligning 12 disparate nations into a cohesive community will be a challenge, Rufenacht says. "I think you can hardly compare Europe to the United States, where everybody is able to work together. There are traditions in Europe that are different—in France, they will always be speaking French; in Italy, Italian. The cultural differences here are much more important than Americans can imagine. An economic community? Yes. Something like the United States of Europe? I don't think so."

Weiderpass, whose responsibilities at Swatch include marketing the company's products throughout Europe, agrees. Because of the language barrier, "there is no 'pan-European' media and there never can be. We design tailor-made advertising campaigns for each country, working hand in hand with translators so that the correct intent of our message gets across. In the United States, a New York advertising agency can write a single K-Mart ad and use it coast to coast. We could never do that in Europe."

Both Rufenacht and Weiderpass agree that recent changes in the political and economic structures of Eastern European nations will only serve to complicate the road to a unified Europe.

"A major problem," says Rufenacht, "will be German reunification. Countries like Hungary, Czechoslovakia and Bulgaria are not considered part of Western Europe, but Germany always has been. If the pressure in Germany is toward a quick reunification, that might endanger the development of the EC. I don't think France or England will easily accept reunification. It might set the program back a couple of years."

Weiderpass agrees. "A unified Germany would have a mega-effect on the EC. West Germany is already the most prosperous country in the community. If it united with East Germany, the country would have a population of 77 million and would be the dominant force in the Common Market.

"People don't talk about it much," he adds, "but some are observing, ironically, that Germany is winning, through the EC, the dominating role that it sought by waging two unsuccessful world wars."

—Bonnie Gelbwasser and Ruth Trask

EXPLORATIONS

Developing a More Enlightened Foreign Aid Policy

Interactive Qualifying Project by Bruce C. Duncan '90 and Timothy J. Hilchey '90.
Advisors: Hossein Hakimmashhadi, associate professor of electrical engineering, and Tom Hartvig Thomsen, associate dean of students.

Duncan and Hilchey compared the foreign aid policies of the Carter and Reagan administrations to determine how political considerations influence the disbursement of monetary aid to foreign countries. They also compared the aid policies of the United States and Denmark to see whether different approaches have led to markedly different outcomes, and whether a new course needs to be charted for the United States' foreign aid policy.

Dating back to the American Revolution, when foreign aid helped American colonists defeat the British, the United States has been inclined to help friendly governments in time of war, crisis or disaster. Today the U.S. provides financial and technical assistance to about 80 nations around the world.

But political and strategic concerns, rather than altruism, seem to determine which countries receive the lion's share of U.S. aid, the students say. Since the 1940s, U.S. foreign policy has been strongly influenced by a desire to contain the spread of communism around the world. This foreign policy goal has remained constant from administration to administration.

In contrast, Denmark's foreign aid policy is based on supporting economic and social programs for the poorest of the world, in dialogue with their governments.

Despite their political differences, the Carter and Reagan administrations differed little in their approach to foreign aid, Duncan and Hilchey report. While Reagan boasted of tying foreign aid to the goals of U.S. foreign policy and Carter emphasized a more humanitarian approach, both administrations placed military aid above either emergency or development assistance.

The students say they agree with David Wall, who wrote in *The Charity of Nations* that since the Second World War, U.S. administrations have believed that "aid caused economic growth, which in turn promoted social progress, which in turn promoted political stability, which furthered the security of the United States."

Unfortunately, they say, this has resulted in nations like Turkey, Greece, Pakistan, South Korea and pre-1979 Iran—which are located on the periphery of the Eastern Bloc—receiving large sums of military and economic support funds, while countries whose residents or leaders do not cleave to U.S. political or economic models are far less likely to receive support.

In the future, the students note, the U.S. "should strive for peace and justice among the nations of the world [and] work toward securing the human rights of every inhabitant on the planet. The people of the United States should expect no less from their government."

Biogas: A Solution to India's Energy Needs?

Interactive Qualifying Project by Ajoy B. Patel '89 and Narayanan Rajan '90.
Advisor: Patrick P. Dunn, associate professor of history.

About 75 percent of India's population lives in rural areas and struggles to meet its needs for sustenance and shelter. Providing low-cost energy to pump water and cook food is a major challenge, as is increasing low crop yields caused by insufficient and improper use of fertilizer.

Patel and Rajan say they believe that the solution to both problems may be biogas technology: the anaerobic (air-free) digestion of biodegradable waste products like manure, water hyacinths and agricultural residue. The process produces energy in the form of methane gas as well as nitrogen-rich fertilizer in the form of a slurry. It could have the added benefit of minimizing India's dependence on fossil fuels.

Many Indian farmers already use dung both as fertilizer and as fuel for their earthen stoves. Biogas technology makes these age-old practices more efficient and safe, alleviating, for example, production of the carcinogen benzopyrene.

The heart of a typical biogas plant is a digester tank where microbes break down waste products over the course of 30 to 40 days. The units can be set up to maximize the production of either methane, which can be burned in stoves, lighting fixtures and vehicle engines, or fertilizer, as the needs of the community dictate.

Patel and Rajan spent the summer of 1989 in India, where they examined the technical and socio-economic aspects of using biogas technology and researched its history. Starting in 1980 the Indian government began to build and staff biogas plants in rural areas. By 1981 there were about 110,000 plants in operation.

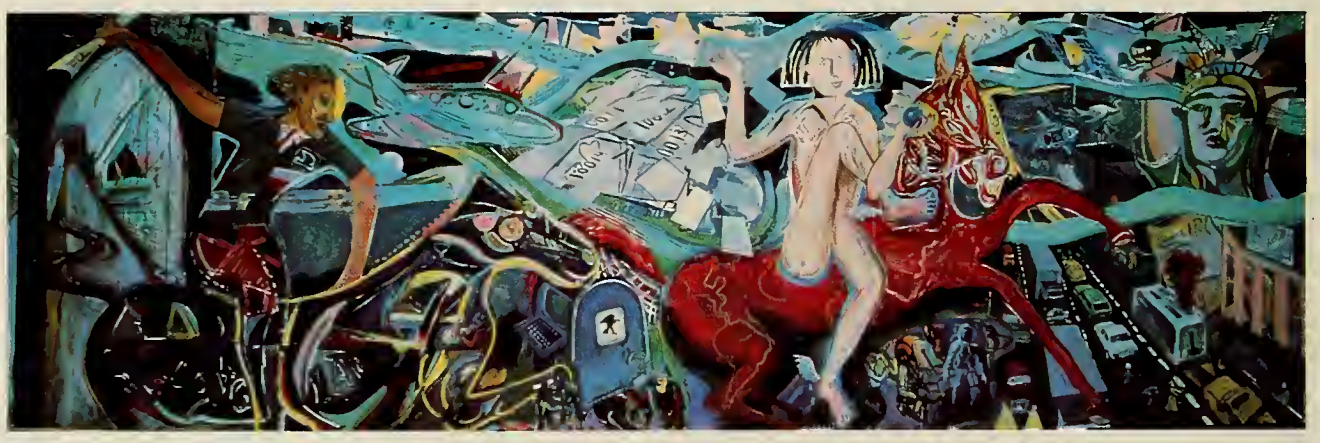
Still, the students say the biogas program has not been completely successful. Residents have been reluctant to allow this technology into their communities. In addition, developers have had problems receiving financing, obtaining cement for construction and finding high-quality stoves and lamps for use with the systems. Since existing systems can run only on manure, they can be used only in areas with cattle farms.

Still, despite its problems, Patel and Rajan say biogas technology has a future in India.

—Bonnie Gelbwasser

FINAL WORD

Wake up, Moscow! Rabinovitch is Coming!



***Liberty Overture*, a 1987 mural, is on permanent display in New York City's Canal Street Post Office.**

This spring Moscow is in for a delightfully energetic change of pace: a major one-man exhibition of paintings by Soho expressionist William Rabinovitch '58. If shivering Muscovites are yearning for a warming trend following a long, cold Russian winter, they might try basking in the heat of the blood-stirring Rabinovitch canvases that will be on exhibit near Red Square in April.

Rabinovitch captures energy that can barely be contained within the confines of his canvases. Whether murals or portraits, his work is characterized by a sense of perpetual motion.

He is concerned with capturing inner values, rather than achieving realistic depictions. His work occasionally shows hints of Gauguin, Picasso and even the pyramid muralists. Some of his paintings have the qualities of a patchwork quilt or a kaleidoscope. Says Rabinovitch, "My paintings break away from things as they are, in order to show figures and events in process."

Early in his career Rabinovitch, a mechanical engineer by training, served as an aerospace engineer and Air Force pilot. "They wanted me to fly B-47s in Alaska," he says. "I finally came to my senses and quit."

He went into painting almost by accident. "While I was working as a planner for American Science and Engineering in Cambridge," he explains, "I decided to take a few classes at the Boston Museum School. My company paid for the courses. I liked art so much that I left my job and moved to the West Coast to study painting full time."

He studied at the Whitney Independent Program and the San Francisco Institute, where he earned his M.F.A. in painting. It was during these years that he developed his unusual style.

He has had many one-man shows at a variety of locations, including the Ingrid Cusson and the Neil Pearson Esq. galleries in New York City; the Monterey Jazz Festival, the Monterey Peninsula Museum of Art and the Triton Museum in California; the Casa Americana in Madrid, Spain; and at WPI in 1983. His work has appeared in group shows at the San Francisco Art Institute, Rutgers National Works on Paper, the Allentown (Pa.) Art Museum, and the Vorpal Gallery in New York.

One of his best known murals, "Liberty Overture," is on permanent display at the Canal Street Post Office in New York City. Three major figures fill the piece. A horse with rider is symbolic of the daily commuter, Rabinovitch explains, while a central female figure represents the Post Office as a muse of the mails, distributing letters to the proper zip code areas. Facing Canal Street is the Statue of Liberty, which seems to be very much alive—suggesting not only the monument's inner life, but also the dynamic character within the concept of liberty.

Rabinovitch says, "My experience in painting this particular mural was an adventure into new dimensions of scale and color."

A New York critic described the work as "rambunctious, disorthodox and altogether entertaining....I am always marvelously on edge around [Rabinovitch's] work."

Rabinovitch is an established star in the American art scene. He is included in *Who's Who in American Art*. His work has been reproduced in *Art News, New York Art Review, Cover, New Jersey Artform, Anderson and Archer's Soho* (published by *Art in America*), *Arts Magazine*, and *Print World Directory*. His paintings grace the walls of the College of Mount St. Vincent in Riverdale, N.Y., Peninsula College in Monterey, Calif., the Fairmont Hotel in San Francisco, the Mercedes Benz Showroom in San Rafael, Calif., and the New York City Runners' Club. He has also exhibited in numerous art shows and at a number of galleries and museums, including Sotheby's and the Whitney Museum, both in New York City.

Aside from public displays, Rabinovitch's paintings and sculpture have appeared in set designs for several films. Two feature films, *Playgirl* and *Born to Run*, relied on his art to represent the work of the main characters.

In January 1989 Rabinovitch served as artist-moderator for the American Expressionism panel of the Artists Talk on Art forum held at the Soho 20 Gallery in New York. Last October a video documentary about his work was shown on television in Los Angeles and New York City. The film was produced by David Howard of San Francisco, who has produced a number of documentaries about other well-known artists. Recently other videos about his work appeared on "Images/Art New York," a local television show.

In 1977 Rabinovitch was one of the founders of the now defunct Whitney Counterweight, a group of Soho galleries that displayed avant-garde work countering the work of traditional artists at the uptown Whitney Museum of American Art. He says Counterweight art "tended to be more expressionistic, involved with strong colors and brushwork and a sense of pain and struggle."

It also tended to be uniquely experimental. For example, one Counterweight artist "solar painted" by burning holes in canvas through a magnifying glass hung on a string.

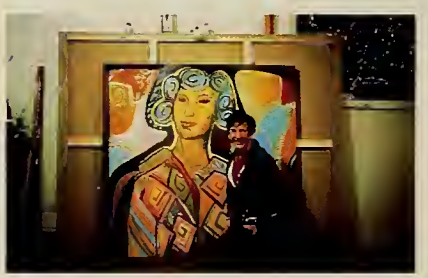
Rabinovitch also uses a variety of nontraditional substances and materials, including acrylic, glitter, paving stones, and Styrofoam, in his paintings and sculptures. He often borrows from his technical background. In the January 1989 issue of *Cover* he discussed his ideas for using three-dimensional computer graphics and video technology to animate his paintings.

At the moment, however, Rabinovitch is looking forward to his upcoming visit to the Soviet Union. "I'm very excited," he says.

He's excited? Just wait until staid Moscow gets a load of Rabinovitch.

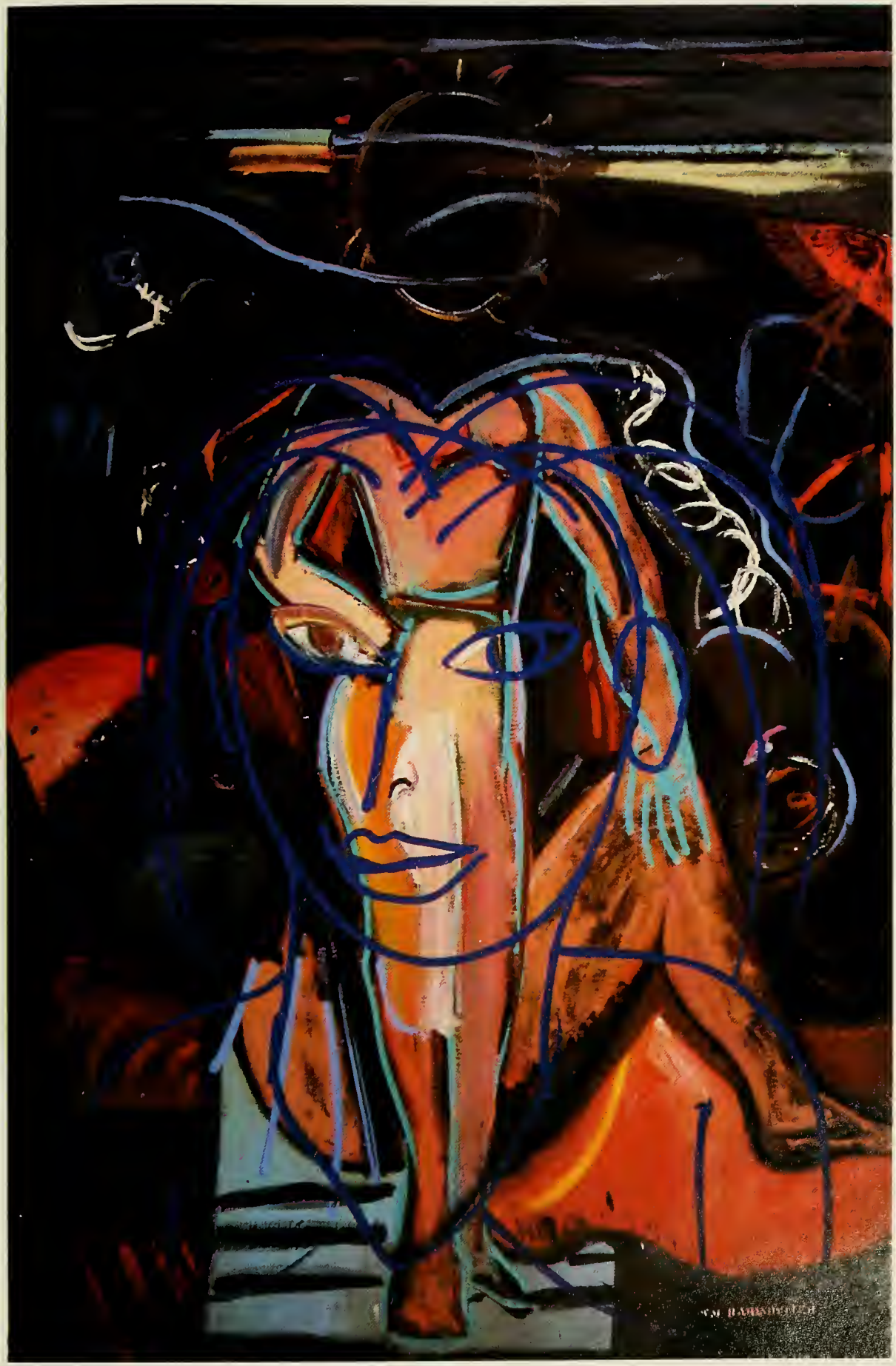
—Ruth Trask

Rabinovitch's interest in experimenting with nontraditional materials is evident in these works: *Woman and Horse* (top), 1983, and *Western Rider* (bottom), 1980, both painted with acrylic and glitter on canvas.



(Clockwise from right, all paintings acrylic on canvas) *Mood Figure*, 1989; *Soho Couple*, 1987; *Goddess*, 1988; the artist in his Soho studio with a work in progress. "Rambunctious, disorthodox and altogether entertaining," said one New York critic of Rabinovitch's work.

An anonymous donor contributed to the printing of this article.



EXCELLENCE IS...

Maintaining Modern Teaching Laboratories

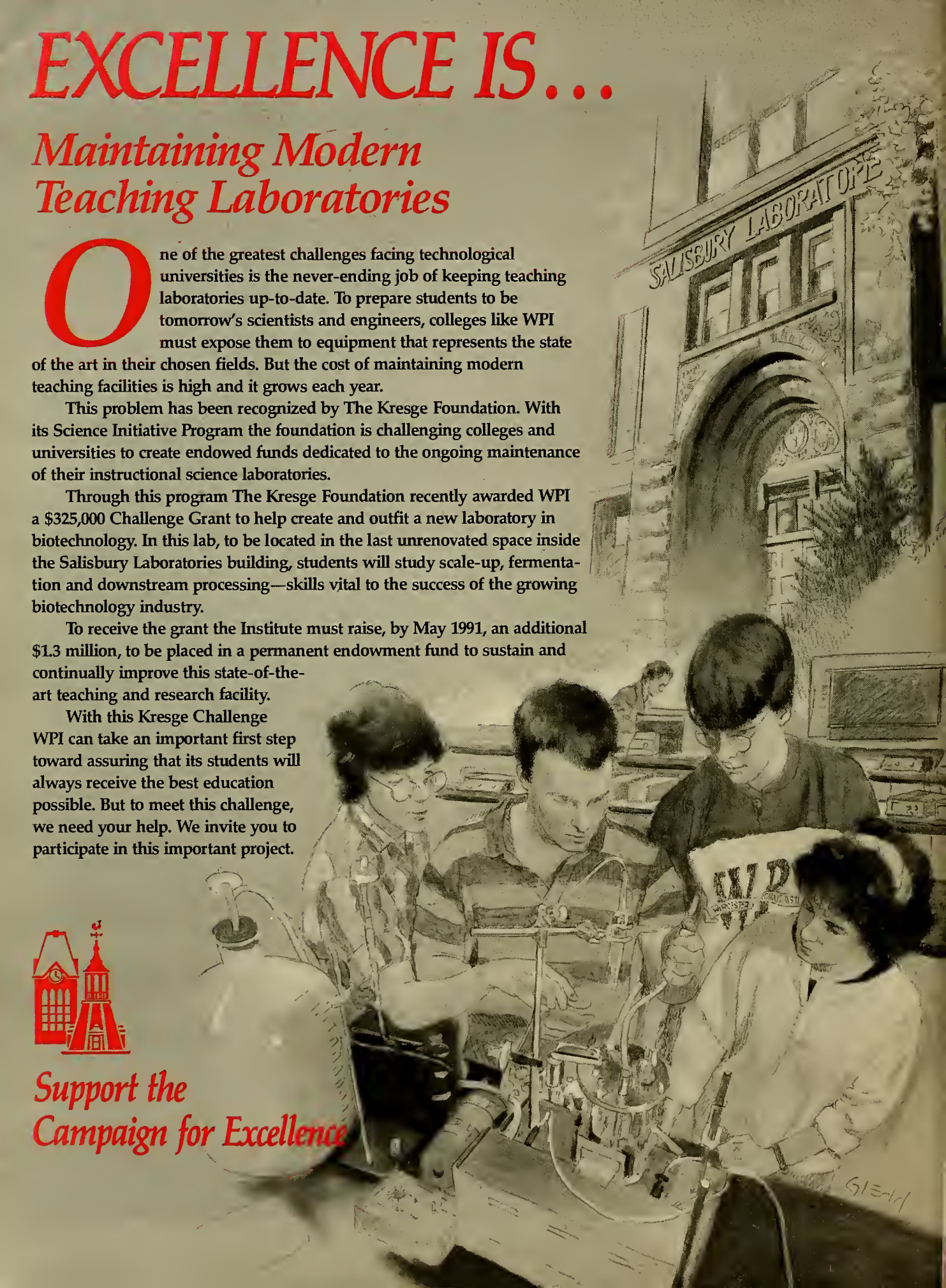
One of the greatest challenges facing technological universities is the never-ending job of keeping teaching laboratories up-to-date. To prepare students to be tomorrow's scientists and engineers, colleges like WPI must expose them to equipment that represents the state of the art in their chosen fields. But the cost of maintaining modern teaching facilities is high and it grows each year.

This problem has been recognized by The Kresge Foundation. With its Science Initiative Program the foundation is challenging colleges and universities to create endowed funds dedicated to the ongoing maintenance of their instructional science laboratories.

Through this program The Kresge Foundation recently awarded WPI a $325,000 Challenge Grant to help create and outfit a new laboratory in biotechnology. In this lab, to be located in the last unrenovated space inside the Salisbury Laboratories building, students will study scale-up, fermentation and downstream processing—skills vital to the success of the growing biotechnology industry.

To receive the grant the Institute must raise, by May 1991, an additional $1.3 million, to be placed in a permanent endowment fund to sustain and continually improve this state-of-the-art teaching and research facility.

With this Kresge Challenge WPI can take an important first step toward assuring that its students will always receive the best education possible. But to meet this challenge, we need your help. We invite you to participate in this important project.



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WPI Journal

WORCESTER POLYTECHNIC INSTITUTE SPRING 1990

125 Years of Worcester Polytechnic Institute

EXIT

WPI JOURNAL

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SPRING 1990

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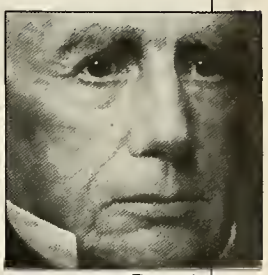
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Cover: The start of a journey. WPI's first two buildings, Boynton Hall on the left and the Washburn Shops, shortly after the college opened its doors to the youth of Worcester County. Story on page 4. Opposite: Past, present and future came together as WPI dedicated the new Fuller Laboratories. Story on page 26. Photo by Janet Woodcock.

ADVANCE WORD

Two Buildings, One Dream

Church bells all over Worcester rang out in mourning on September 30, 1904, observing the death of one of the city's most esteemed citizens. A veteran of 36 years on Capitol Hill, Senator George Frisbie Hoar was, at the age of 78, among the most respected and loved elder statesmen in Massachusetts.

Hoar's death also had great significance for WPI, for he was the last of a group of seven men who had taken the simple and earnest proposal of an elderly tinware manufacturer and turned it into a well-respected college of engineering and science.

In this special issue of the *WPI Journal* we chronicle the story of those men and the events they precipitated—events that culminated, on May 10, 1865, in WPI (known then as the Worcester County Free Institute of Industrial Science) receiving its charter from the Commonwealth of Massachusetts. To help mark the 125th anniversary of that beginning, we've put together a 22-page section on the early history of the Institute, starting on page 4.

The story of WPI can be found not only in a chronicle of its events and people, but in the lines and arches of its buildings. In these facades are clues to the forces and events that shaped the college. For example, the stately granite tower of WPI's oldest building, Boynton Hall, embodies the dreams and aspirations of the men who founded the college and built it from the ground up—men who knew the value of preparing students to forge new generations of technology for a growing nation.

It's appropriate, then, that WPI chose to celebrate its 125th birthday on May 10 by dedicating its newest building, the $10-million George F. Fuller Laboratories. Reflected in Fuller's crisp brick and glass facade are the dedication and vision of the individuals who today carry on the founders' dreams. Reflected, too, in this information sciences building are the tremendous leaps that science and engineering have taken in the years since WPI was born, leaps that are already propelling WPI into a new era of technology. A photo essay on Fuller Labs begins on page 26.

The late George F. Fuller was very much a product of the Machine Age.

There are interesting parallels between WPI's oldest and newest structures. While each of WPI's other academic buildings was built largely through the generosity of a single benefactor, Boynton Hall and Fuller Labs were made possible by the beneficence of a large number of donors. The donors to Boynton Hall included 225 individuals and workers at 20 of Worcester's factories and machine shops.

To construct Fuller Labs, the college challenged many of its alumni and friends, along with a number of philanthropic foundations and corporations, to contribute the needed funds. In all, 1,363 individuals and 16 corporations and foundations have contributed to making this new 61,255-square-foot structure a reality.

There is another important link between these two buildings, constructed more than a century apart. Born the year after WPI opened its doors, George Fuller was very much a product of the Machine Age that gave birth to WPI and Boynton Hall. He was hired just out of high school by Winfield Wyman, WPI Class of 1882, and Lyman Gordon, Class of 1881, to be the bookkeeper in their new drop forging business in Worcester. Wyman and Gordon, both sons of mechanics, modeled their business on the machine shops they had known as young boys. Fuller was drawn to the excitement of this shop environment from the moment he began work. In time, his natural talent for mechanical design and practical problem solving made him a valuable member of the shop team.

While still a young man, Fuller made important contributions to the success of the company. He developed a hydraulic press to make the knuckles for railroad couplings and then created a heat treating process to keep the knuckles from failing in the field. The process was later applied to automobile crankshafts with great success. Wyman-Gordon became one of Worcester's major industrial firms and Fuller ultimately became its chairman. He served the firm for 76 years.

Like WPI's own history, Fuller's life and career spanned an incredible period of technological progress. He guided his company through revolutions in transportation, communication and manufacturing. At the time of his death in 1962, the world was just beginning to realize the benefits of the Computer Age. Now, with a splendid new facility that bears his name, WPI is ready to prepare young men and women to help shape the Age of Information and the technological frontiers that lie ahead.

In compiling this special issue, the staff of the *Journal* made extensive use of the excellent collection of original documents, WPI publications and photographs maintained by the WPI archives. We are indebted to archivist Lora Brueck for her invaluable assistance with this project.

—Michael Dorsey

LETTERS

WPI's 1943 baseball team. Gibson is in the back row, second from the left.

Another "informal" victory

In response to Roger Perry's request for memories of great moments in WPI sports history (Memory Bank, Fall 1989), I submit the following:

Mr. Perry's article covered WPI's 12-0 football victory over an "informal" Harvard team in 1944. The year before, 1943, the WPI baseball team posted a similar victory (10-3) over another informal Harvard team. The win was capped by a five-run rally in the eighth inning.

I'm not sure that the media gave as much coverage to this upset, but we team members were justly proud.

Joseph W. Gibson Jr. '44
Captain, 1944 WPI Baseball Team

Roger Perry provided the following correction to his original story on that football victory:

Thanks to the readers who spotted the error in "Those Championship Seasons" (Memory Bank, Fall 1989). According to no less an authority than the 1944 yearbook, the "game heard around the world" against Harvard was played in 1943, not 1944. And WPI won 13 to 0, rather than 12 to 0.

This bit of WPI folklore is something I've "known" for so long, I didn't feel the need to check the record. It's humbling to realize one's memory can be fallible!

Roger N. Perry Jr. '45

Forseeing dangers ahead

I was intrigued by the article ("A World Apart," Fall 1989) about the many project programs WPI has undertaken abroad. The college prides itself on all the help it gives to other countries that need it.

My only concern is that we may not be doing enough to help our own beleaguered nation. I understand that we have a critical shortage of science teachers in the U.S. and that relatively few young students these days are taking the hard courses, such as math, science, engineering, geography and language.

What's to become of us if we can't compete with all our "friends," such as Japan, Germany and other nations that are beating us at the patent office and in all sorts of electronic applications? We depend almost entirely on Japan, for example, for television and computer technology—vital areas essential to our national defense and general standard of living. Some of these countries treat us very unfairly, while we keep preaching free trade.

Wouldn't it be better to send our WPI students into our own high schools and colleges and convince students there, through talks and demonstrations, that science is a rewarding experience and an area of great need?

Our federal trade deficits have been running in the hundreds of billions of dollars annually for years and threaten our economy and our future. Just how will sending our students abroad to teach other countries our technology affect this serious problem? We may be on the right track, but I can foresee dangers ahead.

Theodore R. Latour '35

A decade too late

I have just opened the Winter 1990 issue of the *Journal* and, to my great surprise, I found my picture opposite page 1. The photograph was taken in August 1948 during the summer surveying classes and was to be used for an article on WPI.

Your caption, "Surveying Boynton Hill in the late 1950s," missed by about 10 years. During the late 1940s WPI had many returning World War II veterans. I was one of them and was wearing an Army Air Force shirt in the photograph.

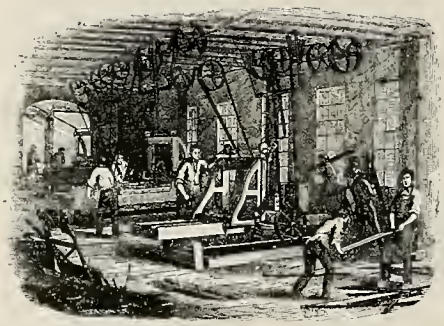
Your article on the Berlin Wall in that same issue also brought back memories. My son John was the sound engineer for the Joe Cocker Band that played a free concert at the wall on November 12, 1989.

John F. Gallagher '50

A New College for a New Era

125 years ago seven men of uncommon wisdom took the dream of an elderly tin manufacturer and gave it life. In the process they set in motion a bold new experiment in education.

By Michael W. Dorsey



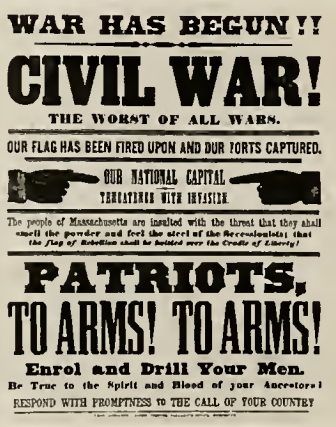
From time to time an innovation comes along with the power to truly change the world. In the 19th century it was the machine. Powered by water or steam, the machine was the driving force of the industrial revolution. It transformed manufacturing, transportation, farming and virtually every other area of enterprise.

With the age of the machine came the need for a new breed of craftsmen and professionals skilled in machine design, construction and repair. Mechanics and machinists, and the machine shops they inhabited, first found a home in the textile mills, where they built the spinning and weaving machinery and kept it running smoothly. By 1825 independent machine shops were emerging to build the steam engines, locomotives and machine tools needed by a rapidly growing nation. By the latter half of the 19th century hundreds of such enterprises, some specializing in just one type of machine, were operating alongside America's thriving mills and factories.

The machine shop was a special place—often as much an experimental laboratory as a metal works and job shop. To solve the complex problems associated with molding and forging raw metal into functional machines, mechanics had to break new ground in metallurgy, machining and manufacturing. Not unlike modern research laboratories, machine shops thrived on the free exchange of new ideas, an open style quite foreign to most of the cautious, close-to-the-vest businessmen of the day.

But while the machine shop provided an ideal environment for training mechanics, it was ill-equipped to address the needs of the emerging discipline of mechanical engineering—a discipline it had helped create. More and more, engineers were being called on to expand not just the practice of their fields, but the theoretical underpinnings of that practice. For that, a firm grounding in higher mathematics and science was required.

By the 1850s the United States was ripe for a revolution in higher education. The country was fast becoming an economic power: in its iron foundries, rail lines and coal mines could be seen the seeds of a new era in American history—one marked by increasing industrialization, a rapid expansion of urban centers and a growing standard of living. Adding fuel to the fires of change, the Civil War, which lay just on the horizon, would put an end to lingering doubts about whether this brash new nation would indeed survive.


WAR HAS BEGUN!!

CIVIL WAR!

THE WORST OF ALL WARS.

OUR FLAG HAS BEEN FIRED UPON AND OUR FORTS CAPTURED.

OUR NATIONAL CAPITAL THREATENED WITH INVASION.

The people of Massachusetts are insulted with the threat that they shall smell the powder and feel the steel of the Secessionists; that the flag of Rebellion shall be hoisted over the Cradle of Liberty!

PATRIOTS, TO ARMS! TO ARMS!

Enrol and Drill Your Men.

Be True to the Spirit and Blood of your Ancestors!

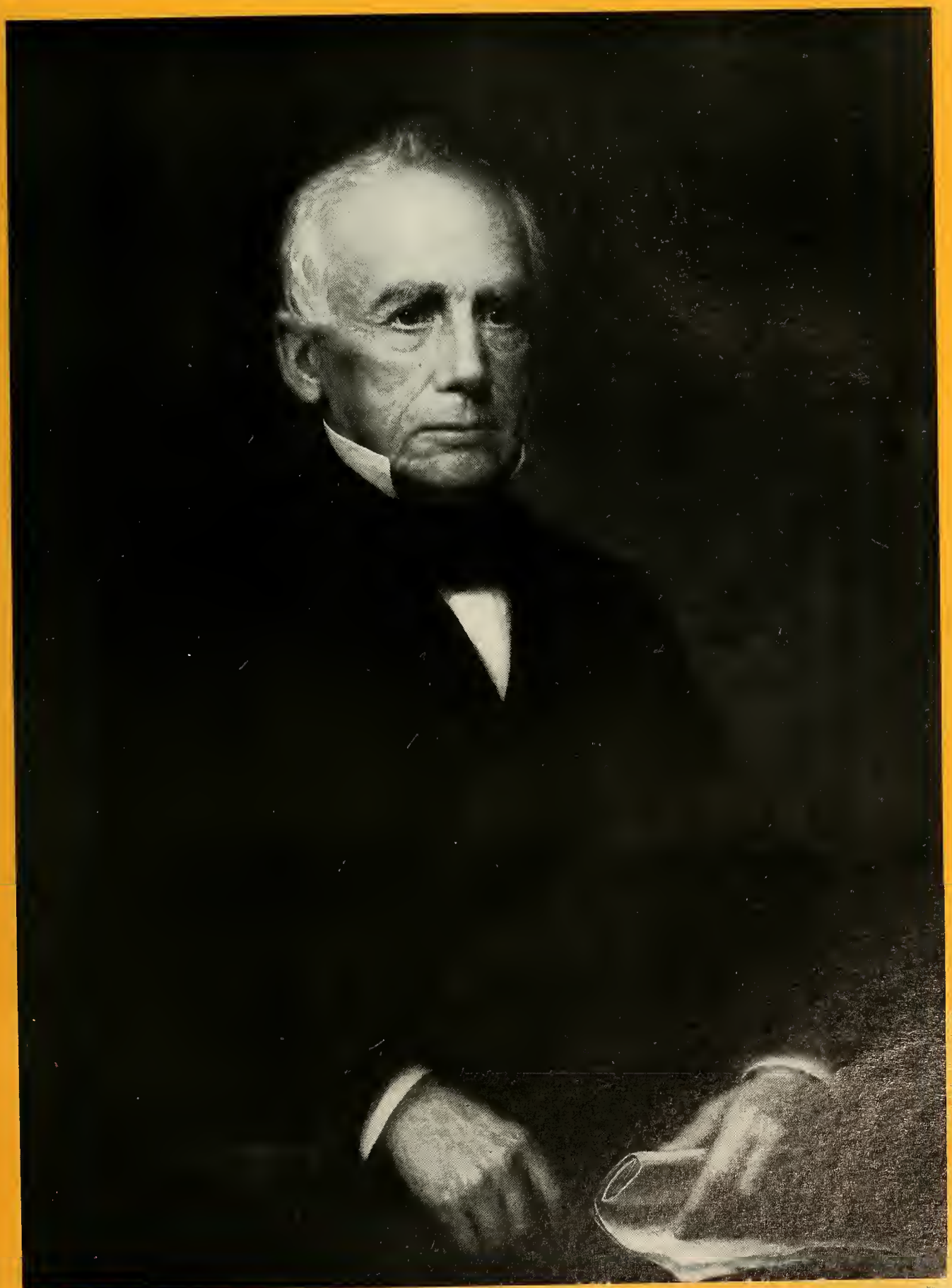
RESPOND WITH PROMPTNESS TO THE CALL OF YOUR COUNTRY

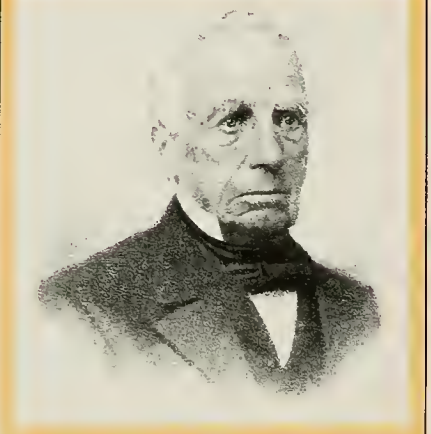
With few exceptions, there were no niches in America's system of higher education for the people who were making this great metamorphosis possible—the farmers, the mechanics and the myriad workers who constituted the rising middle class. The traditional college of the day was, by and large, an institution of the privileged, geared to providing an intellectual and moral education to children of wealth and social position. By 1850, it would find itself out of step with the nation's march of progress.

One man who saw this failing in the country's colleges and universities was Senator Justin Smith Morrill of Vermont. In 1848 he suggested that some of the traditional programs offered by American colleges could easily be "lopped off" and replaced "by those of a less antique and more practical value."

In 1857 he wrote what came to be called the Morrill Federal Land Grant Act, which would allocate large tracts of public land to every state in the union based on population. The land would be

John Boynton relied on others to lay the foundation for his new college.





John Boynton

As Stephen Salisbury observed in a memorial notice read into the minutes of a meeting of the trustees in the spring of 1867, John Boynton had been "modest and reserved in his disposition." By his request the architects of the college he founded kept his name a secret until his death. Naming the college's first building for him was not just a way of honoring his memory, but of revealing, at last, the identity of the mysterious benefactor who had given the Worcester community such a wonderful gift.

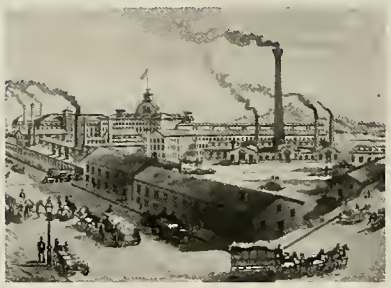
Boynton was born to modest means and lived his life in the careful, thrifty manner of the many who as children had known poverty. Born in 1791, he worked his father's farm in Mason, N.H., until he was 30, then set up a small business in a nearby town to make and sell tinware. He soon moved the business to Templeton, Mass., where he operated it until his retirement in 1846. He left the operation in the hands of his cousin, David Whitcomb, in whom he would later entrust his dream of establishing a college.

At retirement, he served for a short time in the Massachusetts legislature, then moved to Athol, Mass., to become the first president of the Millers River Bank. After retiring from that post he returned to Templeton, where he lived until his death on March 25, 1867. He outlived two wives and had no children, so as he approached the end of his life he pondered how to dispose of the bulk of his estate. He gave some to family members. "In his peculiar, quiet manner," Salisbury said, he gave $10,000 to the public schools in Mason, N.H. (In 1989 the nearby town of New Salem, N.H., which receives support from the Boynton Fund, named a new middle school for him.) The rest he gave to his new college.

The industrial revolution and the Civil War formed a backdrop for the founding of WPI. Worcester's soldiers returned on July 4, 1865, to find their hometown alive with industry. At the city's heart was Ichabod Washburn's company (below).

sold or managed for profit, and with the proceeds, the states would establish and endow public colleges to teach agriculture and the mechanic arts.

President James Buchanan vetoed the legislation, but Morrill refiled it in the midst of the Civil War and it was signed by Abraham Lincoln in 1862. The act ignited an explosion of new colleges and universities and opened wide the doors of American higher education to those who previously had no access to it. In Massachusetts, MIT and the Massachusetts Agricultural College (now the University of Massachusetts) were designated the state's land grant colleges. In New York, which received the largest allocation of public land, Cornell University was granted that distinction.



Founded by Ezra Cornell, who had amassed a fortune as one of the founders of Western Union, the university was one of a new breed of educational institutions that were direct products of the nation's growing industrial wealth. These new institutions included the first colleges dedicated to educating scientists and engineers—especially mechanical engineers. (RPI, founded in 1824, had been the undisputed leader in engineering education for nearly half a century.)

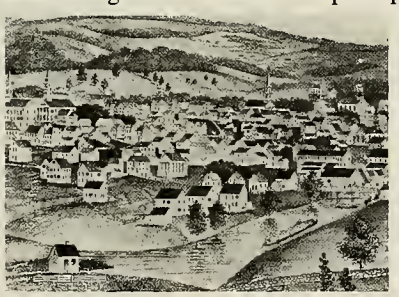
Among the men who shaped these schools there developed a fundamental difference of opinion on how best to prepare engineers for the challenges they would face in their careers. Many belonged to what was known as the "school culture." They believed that classroom instruction and research were the only tools needed to educate engineers. Others, adherents to the competing "shop culture," contended that engineers would be hard pressed to put their knowledge to practical use without the benefit of shop experience.

Perhaps no city in the 1800s epitomized the rewards of the shop culture more than Worcester. By the 1850s Worcester was already widely known as a hotbed of industrial innovation. As it had in many New England cities, the textile industry launched Worcester's industrial age. Without access to a major river, Worcester's industrialists turned early to steam power and branched out to manufacture a dizzying

The Machine Age spurred an explosion of activity in Worcester, transforming it from an agrarian town (below) to an industrial center. The drawing above shows the city as a teeming metropolis in 1878, ten years after WPI opened its doors.

array of products: farm and machine tools, carriages, firearms, musical instruments, shoemaking machinery, wire, emery wheels—even corsets.

A new canal to Providence and emerging rail lines that linked the city to the rest of New England fueled the growth of a truly industrial city in the heart of Massachusetts. Rising above its bustling streets were hundreds of mills and factories built by men who had honed their skills in local machine shops—men who believed deeply in the value of hands-on experience and the worth of a practical education.



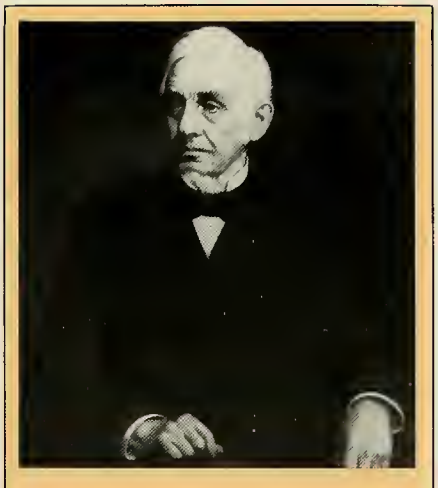
From that belief grew the Worcester Mechanics Association, a professional organization founded, in part, to foster "the moral, intellectual and social improvement of its members." At the association's first meeting a guest lecturer spoke about the importance of educating the mechanics and working men of Worcester County.

One of the founders of the Mechanics Association was Ichabod Washburn, who began his career as a blacksmith and set up his first wire-making operation in the 1830s. By the time the association was launched, the sprawling Washburn and Moen Company had become "the economic cornerstone of the new Worcester," as one writer put it.

In the mid-1850s Washburn formulated an idea for a school to train young men in the principles of mechanics and chemistry. His hope was that the school would receive its funding from the collective wealth of the Mechanics Association members. It was not to be, however. The national economy took a steep downturn in 1857 and capital was in short supply. In fact, the Worcester economy was near collapse by the time the first shots of the Civil War rang out in April 1861.

Although an outsider to the fraternity of Worcester industrialists, John Boynton was a product of the shop culture. He spent his youth as a farmer working his father's land in New Hampshire, then set out to build his own business in Templeton, Mass., making and peddling tinware. Having secured a comfortable fortune, he pursued careers in banking and public service later in life.

Boynton understood how a good edu-



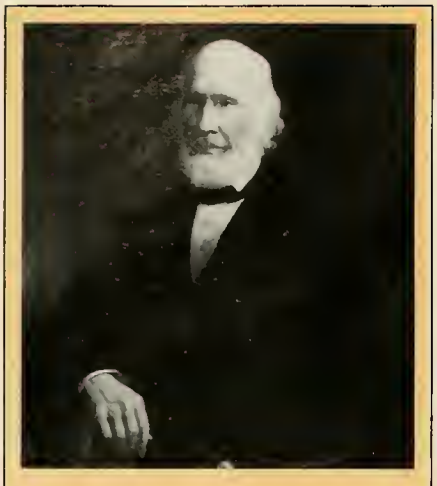
David Whitcomb

David Whitcomb's life is a story of a remarkable triumph over adversity. Born in 1808 to Abner Whitcomb, who had been a minuteman in the Revolutionary War, he was bound out to a farmer at the age of seven. He spent his youth as a chore boy for one farmer or another, finally leaving his hometown of Hancock, N.H., on foot when he was 18.

He worked on a farm for a time and took a few odd jobs before his cousin, John Boynton, hired him as a tin peddlar when he was 21. A year later Boynton made him a partner; in another year Boynton deemed Whitcomb ready to take charge of a branch operation in Leominster, Mass. Boynton retired in 1846 and left the business in Whitcomb's control. Two years later Whitcomb took on a new partner, to whom, in 1853, he sold his interest in the business. Having accumulated a tidy fortune, Whitcomb headed to Worcester to become a partner in a hardware company.

He demonstrated his business acumen when, during the Civil War, he bought large quantities of hardware at panic prices. The transaction earned the business a substantial profit. In 1866, approaching 60 and with the business of getting WPI off the ground well under way, Whitcomb left the hardware firm and, with his son Henry, established the Whitcomb Envelope Company. The firm would grow into one of Worcester's most successful enterprises.

Whitcomb served as a WPI trustee from 1865 until 1884 and was treasurer of the Institute from 1865 to 1876. His son was a trustee from 1884 until his death in 1916. David Whitcomb gave generously to the Institute during his life, his gifts amounting to more than $27,000. He died in 1887 at the age of 79.



Seth Sweetser

While others may have earned the title of formal founders of WPI, Seth Sweetser, perhaps more than any of those present at the birth of the college, helped shape its mission and profoundly influenced its future.

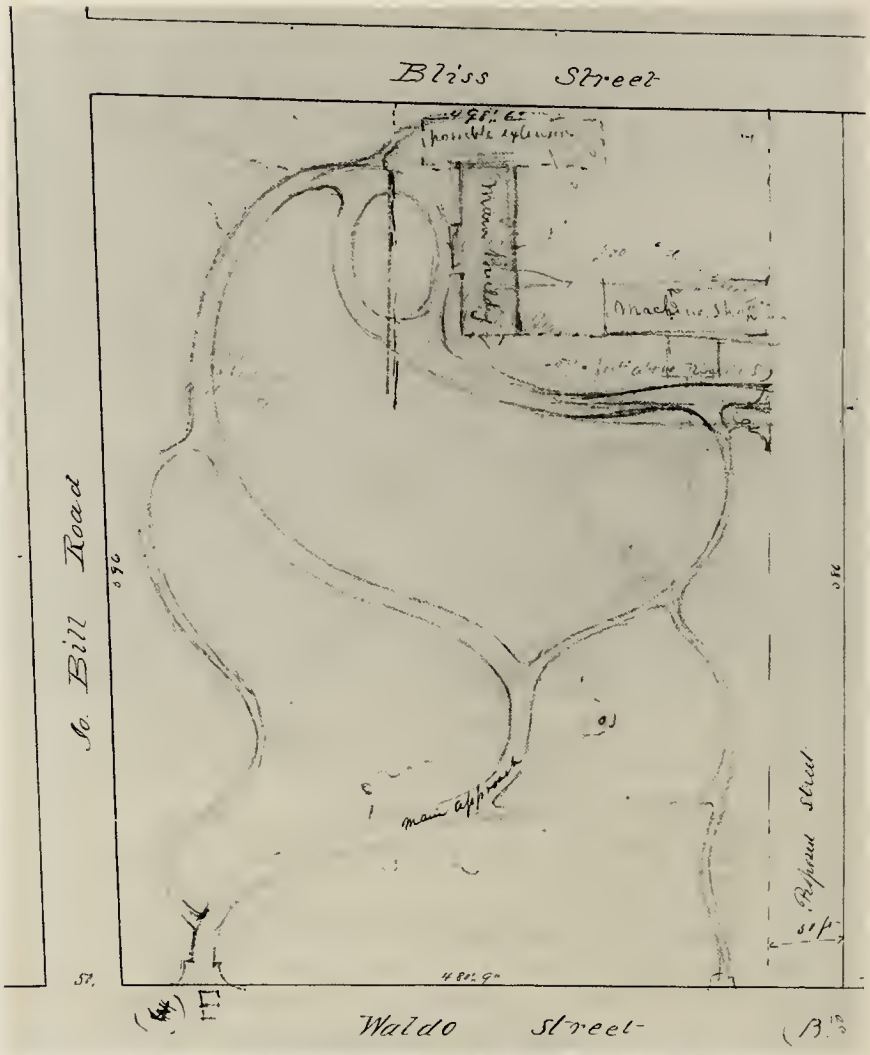
Sweetser was born in Newburyport, Mass., in 1807. After graduating from Harvard, he spent a few years as an instructor and tutor before enrolling at the Andover Theological Seminary, from which he graduated in 1834. He later received a doctor of divinity degree from Amherst College.

He served briefly in a parish in Gardiner, Maine, before being called to Worcester to become the pastor of the Central Congregational Church (now the United Congregational Church). He remained in this post until his death, becoming one of the city's most beloved clergymen.

Deeply interested in education (he was once president of the American Education Society), he served on the boards of trustees of several New England schools and colleges and was associated with Harvard, as an examiner and overseer, for several decades.

He was well-versed in mathematics and science, and was, therefore, well-prepared to help when David Whitcomb brought John Boynton's plan to his attention eight years later. It was largely Sweetser's counsel that led Ichabod Washburn to join in the founding of the new Institute.

Sweetser's contributions to the birth of WPI were acknowledged by Stephen Salisbury II upon Sweetser's death in 1878. Said Salisbury, "Rev. Dr. Sweetser was more than a friend of this Institute; he was more than the leading member of the Board of Trustees; he was the father of this institution."



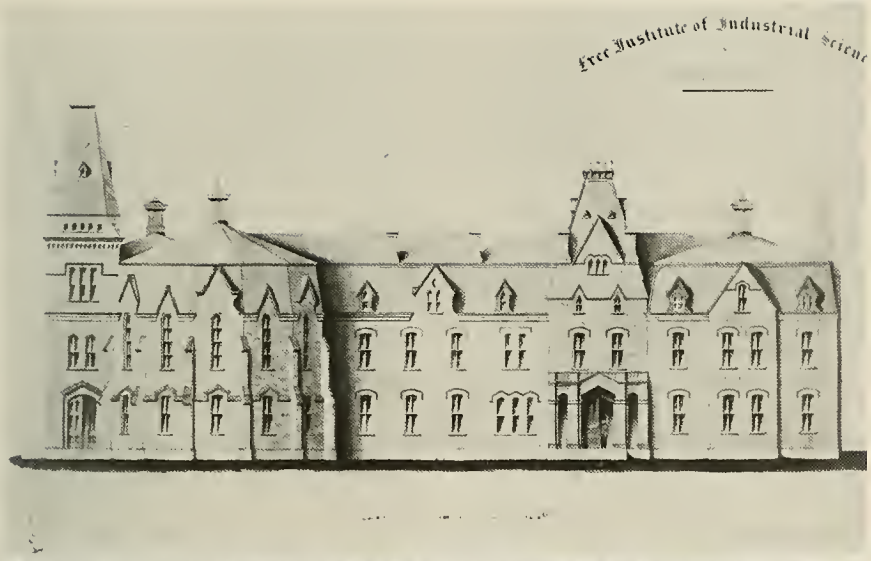
Calvert Vaux, designer of New York's Central Park, sketched this plan for a network of roads and paths leading to the college's first two buildings.

cation can expand one's horizons, despite his own limited schooling. He is said to have helped young men from his own community attend college. It should have been no surprise then, when, in declining health at the age of 73, he resolved to devote his life's savings to the creation of a school where students could receive a practical education. In reality, this bit of enlightened philanthropy caught Worcester completely unprepared.

By the time John Boynton traveled to Worcester in late 1864 to visit his cousin, David Whitcomb, the decade was already shaping up as a time of great scientific and technological advancement. The first practical internal combustion engine had been perfected, Pasteur's germ theory of fermentation formulated, the speed of light measured, and the first open-hearth steel furnace put into production.

Within a year German chemist F.A. Kekulé would explain the structure of aromatic compounds, James Clerk Maxwell would publish his "Treatise on Electricity and Magnetism" and Gregor Mendel would enunciate his Law of Heredity. And everywhere telegraph wires crisscrossed the countryside, linking Americans together in instant communication and providing booming business for Ichabod Washburn and his wire mill.

The internal strife that had wracked the U.S. for three years was nearing its end. In recent months Ulysses S. Grant had taken over the battle-weary Union armies and General Sherman had spread his swath of destruction across Tennessee and Georgia. While the nation was in turmoil, its boundaries continued to stretch toward the Pacific. Since the beginning of 1863, West Virginia and Nevada had become states and Arizona, Idaho and Montana had been organized as territories.



Eminent Worcester architect Elbridge Boyden submitted this design for WPI's first building. The college chose instead the work of the young Stephen Earle.

For Boynton, David Whitcomb was not just a good friend and relative, but a bridge between the rural world Boynton knew and the bustling metropolis of Worcester. Having been a partner in Boynton's business for several years, Whitcomb had sold his interest in 1853 to become a partner in a successful Worcester hardware business. Later in life, he would found an envelope manufacturing firm that would become one of Worcester's most successful industries.

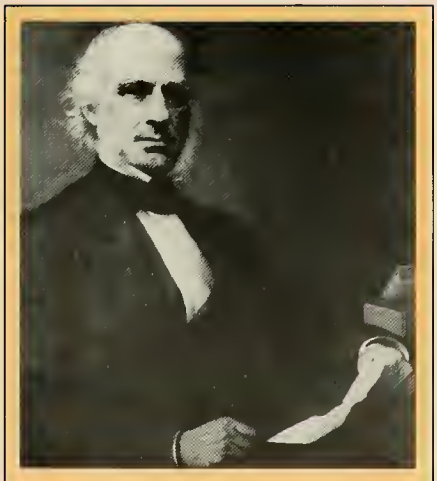
In 1864 Whitcomb was very much a part of the frenetic industrial community of Worcester, which then had a population of 30,000. He was intrigued by his cousin's proposal to create a school and persuaded Boynton to establish it in Worcester, not in Templeton as Boynton had planned. The suggestion of Worcester was a wise one, for Boynton's founding gift would be too small to both endow the new school and build it a campus. Having made his intentions known, Boynton left in Whitcomb's hands the task of organizing the work that followed—work that would turn his germ of an idea into a functioning institution.

"The subject was submitted to us in a very indefinite form, the only direction given being that the money should be devoted to the promotion of education in the County of Worcester. The leading idea communicated to us was that the donor wished to make the avails of his industry a permanent means of aiding the young in obtaining advantages and privileges in preparing for active life, which had been beyond his reach." That is how Seth Sweetser remembered his introduction to Boynton's proposal.

A prominent Worcester clergyman and scholar, Sweetser was often sought out by Worcester residents in need of counsel. In fact, it was to Sweetser that Ichabod Washburn had turned for help in laying the foundation for his own educational dream. And, it was to Sweetser that David Whitcomb first turned to discuss the mission he had been given. Whitcomb also enlisted the aid of Worcester native Emory Washburn (no relation to Ichabod). Washburn had left a successful Worcester law practice to become governor of the Commonwealth in 1853. Having a keen interest in education, the Bussey Professor of Law at Harvard University was also a trustee at Williams College and would later serve as a Harvard Overseer.

Sweetser and Washburn agreed to take on the challenge of nurturing the seed of an idea Boynton had planted and seeing what fruit might grow. They consulted a number of leaders in education, including the president of Harvard and Massachusetts' secretary of education, as they began formulating a plan for the new institution.

Sweetser drew together what he understood of Boynton's intentions (although at the time he did not know the identity of the man whose dream had been entrusted to him). Following the advice he and Washburn had received from their consultants, Sweetser wrote a letter of



Emory Washburn

Washburn was born in Leicester, Mass., in 1800 to an old New England family. Among his ancestors was a member of the first Pilgrim company to set foot on Plymouth Rock and the first secretary of the Massachusetts Bay Company. His father died when he was seven and his mother saw to the details of his accelerated education. He enrolled at Dartmouth College at age 13 and transferred to Williams College two years later when one of his professors became president of that institution. At 17 he graduated and began the study of law.

He was admitted to the bar in 1821 and returned to his hometown of Leicester to begin his law practice, serving for a time as the town clerk. He served Leicester in the state legislature until the death of his mother in 1828, when he moved to Worcester to take a post as an aide to the governor of Massachusetts. As a state representative, he suggested that the state build a rail line between Boston and Albany before Massachusetts had a single mile of railroad. In 1838 he won election to the U.S. House of Representatives, moving on in 1841 to the U.S. Senate, where he chaired the Judiciary Committee for two years. He served as a justice on the U.S. Court of Common Pleas for four years before making his way back to Massachusetts to run for governor.

When the election results were counted in the fall of 1853, Washburn was in Europe. He did not learn of his victory until he deboarded a ship in Halifax, Nova Scotia. His term as governor lasted just one year, and shortly thereafter he was named Bussey Professor of Law at Harvard University. Between his appointment and his resignation in 1876, he wrote more than 50 books and pamphlets. He died two years later at the age of 78.

George Frisbie Hoar

Hoar was already a rising star in Massachusetts politics when WPI was founded. Born in Concord, Mass., in 1826 to a prominent Massachusetts family, Hoar counted among his ancestors an early Harvard president and a state senator. His father served in the state senate and the U.S. Congress.

After graduating from Harvard and the Harvard Law School, Hoar came to Worcester to read law. He chose Worcester because of its reputation as a stronghold of the anti-slavery movement—his father was once driven from Charlestown, Mass., while working to protect the rights of black seamen, a memory that stuck with Hoar.

Hoar eventually established his own practice in Worcester and became quite successful. In 1849 he decided to follow in his father's footsteps and enter politics. He became chairman of the Free Soil Party in Worcester and, in 1851, won election as the youngest member of the Massachusetts General Court.

He later ran successfully for a seat in the state Senate and, in 1868, was elected to the United States Congress. In 1877 his career took him to the U.S. Senate, where he served for 27 years. He was chairman of the 1880 Republican National Convention that nominated James Garfield for president.

In Worcester, Hoar was instrumental in establishing the city's public library and was active in many Worcester organizations. So beloved was he of the city's citizens that when he died in 1904 a committee was immediately established to raise funds for his memorial. With $20,000 donated by 30,000 Worcester citizens, the committee commissioned Daniel Chester French to design a bronze statue of Hoar that stands near City Hall.

instruction for Boynton to sign. It said, in part, "The aim of this school shall ever be the instruction of youth in those branches of education not usually taught in the public schools, which are essential, and best adapted to train the young for practical life."

In early March 1865 Sweetser and Washburn wrote to 30 carefully selected gentlemen in the city of Worcester to test the idea. They would later be called upon to provide the bulk of the institution's financial support. Receiving a favorable reaction, Washburn and Sweetser invited those 30 men to a meeting at the offices of Worcester lawyer George Frisbie Hoar.

Hoar had been elected to the Massachusetts House at the age of 39 and was, in 1865, a member of the state senate. (In the decades to come his political acumen would carry him to the U.S. Senate and make him a legend in Worcester politics.) Among the men who assembled in Hoar's office on March 27 was Ichabod Washburn, still reeling from the contents of the letter written by Sweetser and Emory Washburn. To subscribe to Boynton's plan, he knew he would have to give up his long-nurtured dream of founding his own technical college. By all accounts, it was a painful decision.

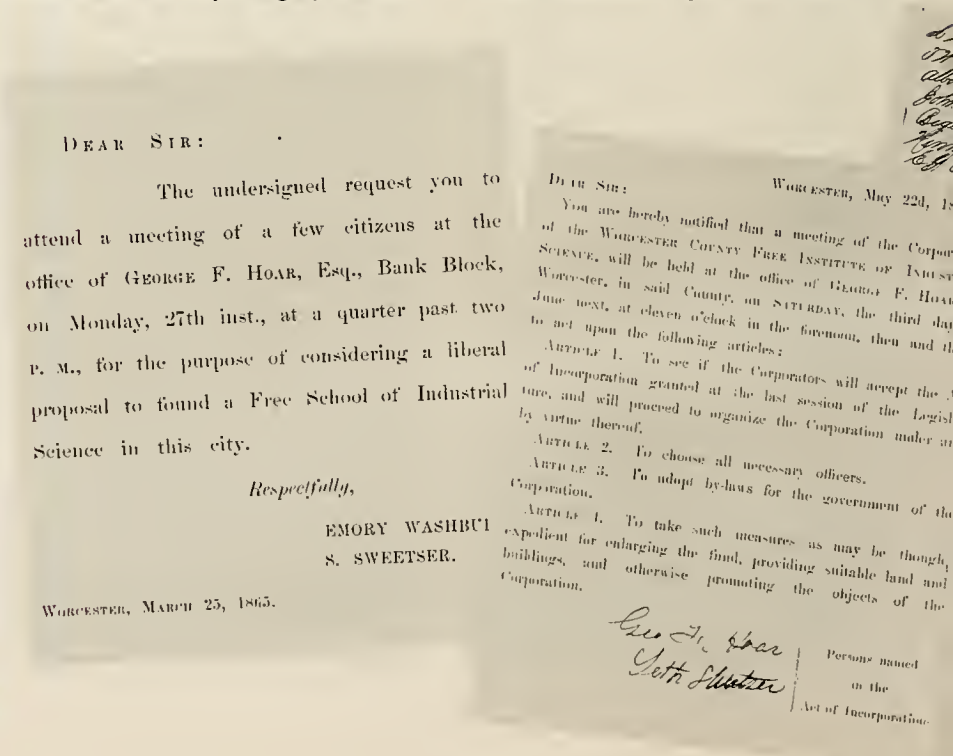
Also at that meeting was 67-year-old Stephen Salisbury II, son of a wealthy merchant, a Harvard graduate and a member of the Massachusetts bar. Salisbury was, in many ways, the leading citizen of Worcester. Later he and his only son would leave the city a legacy that still enriches its cultural life. Securing his interest and support would go a long way toward making the plan a reality.

The assembled group began a subscription list to raise the needed funds for the college buildings and apparatus. One might expect that men who had made their fortunes through hard work and frugality would not leap at the chance to spend a portion of their money on an idea so recently put before them. But they did, and with great enthusiasm and confidence. They concluded their meeting by adopting this resolution:

"Resolved that this meeting recognized, with profound thankfulness, the liberal and philanthropic spirit of the proposition made to this meeting and that we cannot doubt that it will receive the hearty cooperation of the citizens of Worcester."

Ichabod Washburn had spent the past few weeks mulling over his decision. In the end, he agreed to fold his own plans into those for the new institution. On the original subscription paper he penned his pledge to build on the new campus—for a sum not to exceed $10,000—a fully equipped machine shop where students would learn the mechanics trade by apprenticing to practicing professionals. Later he would pledge $50,000 to endow the facility. This clever move added a new dimension to the plans for the college and indelibly left Washburn's stamp on the institution.

With Washburn's gift, the school



DEAR SIR:

The undersigned request you to attend a meeting of a few citizens at the office of GEORGE F. HOAR, Esq., Bank Block, on Monday, 27th inst., at a quarter past two P. M., for the purpose of considering a liberal proposal to found a Free School of Industrial Science in this city.

Respectfully,

EMORY WASHBURN
S. SWEETSER.

WORCESTER, MARCH 25, 1865.

DEAR SIR: WORCESTER, May 22d, 1

You are hereby notified that a meeting of the Corpor
of the WORCESTER COUNTY FREE INSTITUTE OF INDUST
SCIENCE, will be held at the office of GEORGE F. HOAR
Worcester, in said County, on SATURDAY, the third day
June next, at eleven o'clock in the forenoon, then and t
to act upon the following articles:

ARTICLE 1. To see if the Corporators will accept the
of Incorporation granted at the last session of the Legisl
ture, and will proceed to organize the Corporation under
by virtue thereof.

ARTICLE 2. To choose all necessary officers.

ARTICLE 3. To adopt by-laws for the government of th
Corporation.

ARTICLE 4. To take such measures as may be thought
expedient for enlarging the fund, providing suitable land and
buildings, and otherwise promoting the objects of the
Corporation.

Geo F. Hoar
Seth Sweetser

Persons named
in the
Act of Incorporation.

(which had taken on the unwieldy name of the Worcester County Free Institute of Industrial Science) placed one foot squarely in the shop culture. In fact, in a letter elaborating on his gift, Washburn outlined his plan for what was essentially a technical school where students would also learn about science. But the architects of the college knew that Boynton wanted more from his institute. The plan they ultimately devised—an experiment many would call it—neatly merged the principles of the shop and school cultures to produce an institution that was not quite a scientific school and not quite a trade school, but something unlike any college that had ever existed.

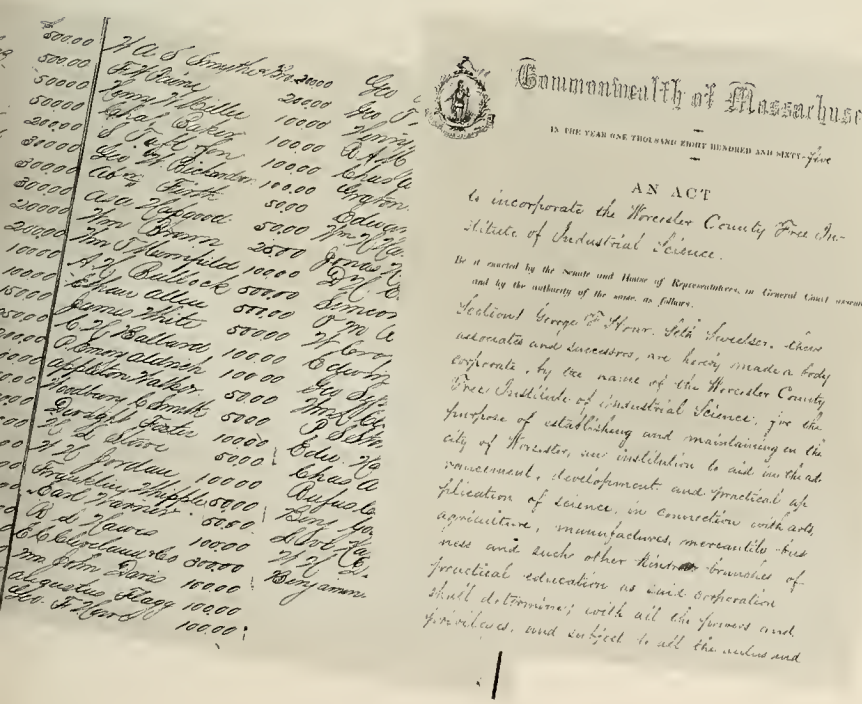
The founders, however, had little time for philosophical discussions—there was business to attend to. By late April, Whitcomb had signed a covenant with Sweetser and Emory Washburn outlining the conditions under which he would release Boynton's $100,000. And, Emory Washburn had drafted a bill that would give the new college legal status.

The bill went before the Massachusetts House on April 26, 1865, and began a speedy passage through the halls of government that would place it on the governor's desk on May 9. The following day it was signed by the secretary of state and the institution today called WPI was born. A few days later, Boynton approved the letter of instruction Sweetser had drafted for him and affixed to it his signature and seal. WPI was one of 14 colleges founded that year, a number that also included Cornell and Lehigh universities.

Having established the intellectual and financial foundation for the new college, Sweetser, Whitcomb and Emory Washburn realized their work had just begun. With charter in hand, the three called the first meeting of the Board of Trustees for June 3, 1865. Also at the meeting were Stephen Salisbury (who was president of the corporation—equivalent to chairman of the board), Ichabod Washburn, George Hoar and Worcester Mayor Phinehas Ball. The only engineer among the trustees, Ball would play an important role in building a campus for the new college.

Ichabod Washburn's machine shop would be an important element of the Institute's physical plant, but the college would also need a classroom building and a site on which to place the two structures. To find out what would be required for the classroom building, Sweetser and Emory Washburn visited RPI, MIT and the Sheffield Scientific School at Yale, and took a look at a new gymnasium at Williams College.

Knowing that the new school's curriculum would, to a large extent, dictate the design for the classroom building, Sweetser and Washburn asked the trustees to name a committee to draw up a course of study. The committee got down to work almost immediately. In its report, delivered in late June, the committee noted that the college's mission should ultimately be to "give instruction in all the different branches which relate the applications of science to the arts of life."



Commonwealth of Massachusetts,

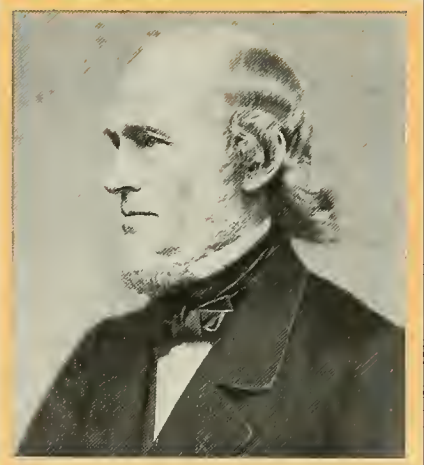
IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SIXTY-five

AN ACT

to incorporate the Worcester County Free Institute of Industrial Science.

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows.

Section 1. George F. Hoar, Seth Sweetser, their associates and successors, are hereby made a body corporate, by the name of the Worcester County Free Institute of Industrial Science, for the purpose of establishing and maintaining in the city of Worcester, an institution to aid in the advancement, development and practical application of science in connection with arts, agriculture, manufactures, mercantile business and such other kindred branches of practical education as said corporation shall determine; with all the powers and privileges, and subject to all the duties and



Ichabod Washburn

Ichabod Washburn and his twin brother Charles were born in 1798 in Kingston, Mass, children of a mariner who died at sea while they were still quite young. Ichabod left home when he was nine and at the age of 16 became an apprentice blacksmith in Leicester, Mass. By the time he was 20, he was a journeyman blacksmith.

After a brief detour in his brother-in-law's mercantile business, he set up his own forge in Millbury, Mass. With a small investment from a Worcester businessman, Washburn moved his business to that city, where he made ramrods, machinery and lead pipe. In 1835 he set up a company with his brother to make wire and wood screws in a building constructed by Stephen Salisbury II.

Washburn invented a new process for drawing iron wire that revolutionized the industry, and his business grew rapidly. In the next few years the brothers created and dissolved several firms, but ultimately went their separate ways.

Ichabod set up a new wire-making company with his son-in-law, Phillip Moen. The new enterprise realized great success with its piano wire. Its work force grew from 120 in 1859 to 3,000 in 1889, and its product line expanded to include telegraph wire, hoop-skirt wire and insulated wire. By century's end, it was the largest company of its type in the world.

Deacon Washburn, as he was known through much of his life, began early in his career to share his wealth with others. In addition to his contributions to WPI, he made possible the construction of Mechanics Hall; founded Memorial Hospital and the Home for Aged Women in Worcester; and contributed liberally to a wide range of educational, religious and charitable institutions in the city and around the region.

Stephen Salisbury II

Through enlightened philanthropy, three generations of men with the name Stephen Salisbury shaped Worcester's most important institutions and, in many ways, made the city what it is today. Stephen Salisbury I came to Worcester from Boston in 1767 to open a branch of the family mercantile business.

His only surviving child, Stephen Salisbury II, was born in 1798. He graduated from Harvard University and remained a scholar of the classics throughout his life. In 1829 he inherited his father's sizeable estate. While he remained a gentleman farmer, he became deeply involved in the life of an increasingly industrial city.

He served in city government and spent four years in the Massachusetts legislature. He extended his generosity to such institutions as the American Antiquarian Society, the Worcester Free Public Library, the Massachusetts Historical Society, Harvard University and the Worcester Mechanics Association.

He was the first president of the Worcester County Free Institute of Industrial Science, a position he held until his death in 1884. His interest in classical education led him to bequeath to the Institute $10,000 as a fund for instruction in languages. Overall he gave far more than the $236,800 in gifts that appear on the college's books.

He survived three wives and had one child, Stephen Salisbury III, who took his father's place on the Institute's board. Stephen III also continued his father's legacy of philanthropy and is best remembered as the founder of the Worcester Art Museum. He donated $100,000 to WPI in his father's memory to build Salisbury Laboratories, and gave the city 18 acres of land to create Institute Park across from campus.

In Elbridge Boyden's conception of the Washburn Shops were echoes of the factory buildings of the day. Below right, Stephen Earle's design for Boynton Hall.

To begin with, the committee said the college should teach mechanical, civil and topographical engineering; chemistry (with special attention to applications in mining, agriculture and the manufacture of chemicals for dying, bleaching and so forth); commercial study (with courses to prepare students to work in the counting house, in banking and in the general management of finance); mathematics; physics; and drawing.

With the committee's report in hand, the trustees developed specifications for the new building. They called for a 14,604-square-foot structure housing a chemical lab, space for a mechanical engineering department, a philosophical apparatus room, lecture rooms, faculty offices, a chapel and exhibition hall seating 200, a library, and rooms for the principal and the janitor. Ball also suggested the building have a roof that could be raised, should extra space be needed in the future, but that feature was not incorporated in the final design.

Four firms submitted designs. The trustees narrowed the choice to those proposed by Elbridge Boyden, designer of Mechanics Hall and the most respected architect in Worcester, and a 27-year-old newcomer named Stephen C. Earle. In the end the board compromised, giving the commission for the machine shop, to be known as the Washburn Shops, to Boyden and choosing Earle to design the classroom building. It would be one of Earle's earliest designs to be built.

Born in nearby Leicester, Mass., Earle studied briefly with Boyden and noted New York City landscape architect Calvert Vaux, and took classes at the Cooper Union, before serving as a medical corpsman during the Civil War. After the war he worked as a draftsman on a major railroad tunnel project in Massachusetts. He toured Europe and in 1865 set up shop with contractor James E. Fuller in Worcester. In a career that would continue until his death in 1913, Earle did much to shape the physical appearance of a rapidly growing Worcester.

For WPI, Earle designed one of the first of many gothic revival "Old Main" buildings that would ultimately appear on college campuses around the country. Its anchoring feature was a four-story clock tower topped by a slate roof. To conserve money, the building, which was originally planned to be a brick structure, would be constructed of granite from local quarries, since the stone was available free to Worcester citizens.

Funds for the building were raised through a general subscription drive. The list of contributors included more than 225 names. Donations were also received from workers at 20 of the city's factories and machine shops. Among the biggest contributors were David Whitcomb, Ichabod Washburn, and James White, who served as construction foreman for the building.

By far the largest gift, $22,000, was provided by Stephen Salisbury II. Salisbury also solved the problem of where to locate the college by donating a six-acre parcel of land near his home. At the same

time he contributed $60,000 to create a fund for "paying the expenses of instruction." (He later donated an additional $50,000 to the fund.) Salisbury's gifts brought the value of the college's funds and real estate holdings to between $230,000 and $250,000—"a larger endowment than any other institution of learning in this commonwealth, if not in the country, ever had at its founding," a local newspaper reported.

Phinehas Ball, a trained surveyor, prepared topographical plans for the land Salisbury had donated. The trustees then decided to hire Calvert Vaux, who, with Frederick Law Olmsted (designer of Worcester's Elm Park), had laid out Central Park in New York. Vaux recommended placing the two buildings on top of a hill at the northeast corner of the lot. He laid them out at right angles with Boynton Hall facing south toward the main approach road. Vaux's plan of roads and paths scaling the steep hillside—designed to provide stunning views of the two new structures—has remained virtually unchanged over the years.

The contract for the construction of Boynton Hall was given to H.N. Tower and T. Raymond, of Worcester, for $55,500 (the final cost for construction, grading, equipment and furniture would ultimately run $75,343.68). Just over a month later, John Boynton contracted pneumonia and died suddenly. The trustees met to adopt a resolution that was a model of simplicity. "Resolved," it read, "that the principal building for instruction of the Worcester County Free Institute of Industrial Science shall be designated and called Boynton Hall, to perpetuate the honored name of the founder of the Institute, and to enlarge the good influences of his wise and liberal benefaction."

While Boynton Hall and the Washburn Shops rose in tandem, the trustees attended to another important detail—appointing the college's first faculty. After receiving refusals from their first and second choices, the trustees appointed 31-year-old Charles O. Thompson, then principal at Arlington High School, as instructor of chemistry and principal of the new school.

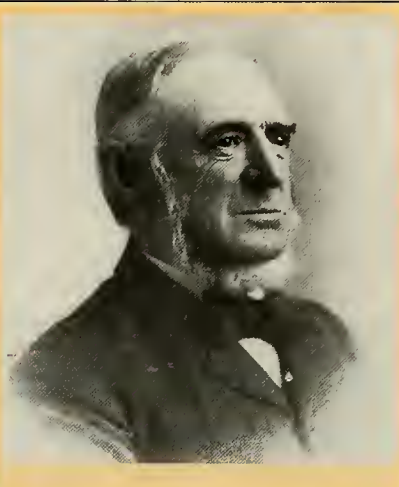
To teach drawing, they chose George Gladwin, an artist with a studio in Worcester. Appointed as mathematics instructor was Harriet Goodrich, Thompson's assistant at Arlington and his wife's sister. George I. Alden, recently graduated from the Lawrence Scientific School, was appointed instructor of theoretical and practical mechanics. Milton Prince Higgins, a recent Dartmouth graduate who had served as assistant to Charles H. Morgan, superintendent of the Washburn and Moen Company, was hired as superintendent of the Washburn Shops.

At 10:30 on the morning of November 11, 1868, the faculty, the trustees and a host of invited guests, including representatives of many New England colleges, climbed Boynton Hill, braving a constant drizzle and mud-filled roads, to take part in the dedication of Boynton Hall and the formal opening of the Institute. Also present were the college's first 32 students, who had begun classes the previous day. Absent was Ichabod Washburn, who was ill at home; he would die before the year was out. The program included a host of speeches and lasted until late in the day.

When the ceremony was over, the participants walked back down the hill in near darkness, leaving behind the tangible products of more than three years of enlightened work. They left feeling satisfied with the new institution they had created and exhilarated by the thought of what it might become in the years ahead. They may well have left with this challenge, spoken by John Woodman of Dartmouth's Chandler Scientific School, still ringing in their ears:

"Let this be the model institution of this region," Woodman said. "Let its plans, methods, aims and spirit pervade and elevate the whole educational system around you. Let its culture, directly and indirectly, in due time, ennoble every person in the region. This can be done. It should be done, and by a single half-century of faithful work, advance this growing population conspicuously beyond their age. And may this city and this institute, from the beneficent illumination today lighted here, become cherished household words by every fireside in every valley of our broad land, from the farthest Maine to the distant Oregon."

Michael Dorsey is editor of the Journal.



Phinehas Ball

Ball was the only trained engineer among WPI's founders. Born in Boylston, Mass., in 1824, he was a sickly youth. As a young man he was sent to live with an uncle in Rhode Island who taught him the principles of surveying. He began working as a surveyor in Boylston, and later studied mechanical drawing and drafting.

In 1847 he went to work for the Nashua and Worcester Railroad as a surveyor. Two years later he went into partnership with Elbridge Boyden, an architect who would later design Worcester's Mechanics Hall and WPI's Washburn Shops. Ball helped lay out several Worcester streets and parts of the city's water and sewer systems.

With the experience he gained in Worcester, he set up shop as an independent engineer. He went on to design water works for several New England cities, including Springfield, Mass., and New Haven, Conn. He patented several devices for use in municipal water systems, including a water meter. With Benaiah Fitts, who had designed a similar meter, he founded the Union Water Meter Company to manufacture the device, serving as president of the company until his death in 1894.

Ball was active in Worcester politics from 1862 to 1872, serving as a member of the Common Council, a water commissioner and the city engineer. He spent just one year as Worcester's mayor—1865, the year WPI was founded. Since his new company did business with the city, he resigned from Worcester government in 1872 to avoid a conflict of interest.

He served WPI as a trustee and secretary for one year and was a member of the board of examiners, which judged the student theses, at the college's third Commencement in 1873.

The End and the Beginning

An Informal History of Commencement at WPI

By Lora T. Brueck

"*Go forth then, young men, to your work. Wherever you are be sure that our best wishes and liveliest sympathy will accompany you. And may the fear of the Lord which is the beginning of knowledge be before your eyes and the blessing of the Lord which maketh rich and with which he addeth no sorrow, rest with you.*"

With these words, on July 26, 1871, Charles O. Thompson, principal of the Worcester Country Free Institute of Industrial Science, sent the 16 young men of the Institute's first graduating class out into the world. Like the 121 Commencement speakers who would follow him in succeeding years, Thompson reminded the class members that they were just beginning their journey on the road of life. Since that July day, more than 20,000 WPI men and women have celebrated the ending and the beginning that is signified by Commencement.

Over the years the ritual of the Commencement ceremony has evolved to suit changing fashions and the inclinations of WPI's 13 presidents. Until 1893, for example, a half day was set aside for the recitation of senior theses and the questioning of seniors by an examining committee and an audience of invited guests. This ritual was not so much a final test of the students' knowledge, as it was an opportunity for the young institution to show off its graduates and facilities.

The gates to Alumni Field are dedicated at Commencement in 1915. Elmer P. Howe (above) was valedictorian for WPI's first graduating class.

Unfortunately, the examiners were not always impressed. In 1880 a principal of a local high school, commenting on the manner of delivery of the theses, said, "The voices of some filled the hall, their enunciation was distinct and their thoughts made intelligible to those of the audience whose previous education enabled them to grasp the subject; but there were more who were awkward in attitude, indistinct in utterance, weak in voice and apparently quite unlikely to convince any body of hearers whose favor they might wish to gain." The principal urged the Institute to provide training in elocution.

The examining committee was com-

posed of between three and 10 prominent engineers, businessmen and educators, including faculty members and presidents of MIT, Harvard, Yale, Amherst and Dartmouth. In 1886 the trustees invited alumni to nominate graduates to serve on the committee, and from then on three alumni served each year.

One of the committee's jobs was reviewing the senior theses after Commencement and making a report to the trustees. The committee members were also charged with inspecting the Institute, which they did, in part, by attending an open house where guests could view student drawings, the apparatus used in instruction and the products of the Washburn Shops. Although the committee was discontinued in 1893, the reading of senior theses at Commencement continued for another three years.

As they have been throughout the years, addresses were a major part of that first Commencement ceremony in 1871. The main speaker was William P. Trowbridge, a professor at Harvard, who spoke on "Applications of Science to Active Business." Principal Thompson delivered his address and Stephen Salisbury II, president of the Board of Trustees, spoke twice. Elmer P. Howe, class valedictorian, gave a "well considered and graceful address" entitled "Agencies in Technical Education," according to a newspaper account of the day. Prayers were offered by the Rev. E. Porter Dyer.

Beginning with the presidency of Ralph Earle, honorary degrees were awarded regularly to alumni, faculty, benefactors of the Institute and leaders in science, engineering and business. The first honorary degrees were granted in 1926 to trustee Charles G. Washburn, brother of WPI founder Ichabod Washburn; longtime trustee George I. Alden, one of the college's original faculty members; A. Atwater Kent, a former student who had earned fame and fortune as an inventor in the field of radio; E.B. Craft, inventor, engineer, and vice president at Bell Laboratories; John E. Aldred, financier of water power and electric utility projects; and Worcester Mayor James Logan.

In time a great many activities were added to the Commencement program, forcing its expansion to four days. A typical Commencement week included the dedication of a class tree, a clambake, class day, a baccalaureate service, a class dance, receptions, addresses, the alumni dinner and a variety of athletic events.

The 1914 graduation week is typical of how WPI Commencements proceeded for many years. The Commencement ceremony itself was set for Thursday, June 11, but the preliminary activities began five days earlier when President and Mrs. Ira N. Hollis opened their 11 Boynton Street home for a Saturday evening dance for seniors and their dates.

On Sunday afternoon, following a reception at the Hollis home, graduates and their guests attended the baccalaureate service. Wearing academic robes for the very first time, the seniors marched together from the campus to Central Congregational Church in Lincoln Square. The sermon, delivered by the Rev. George D. Hodges, dealt with the worth of a man who is willing to serve wherever he is placed—despite the nature of the task.

On Monday a clambake was held in Edgemere on Lake Quinsigamond. Later that day the annual senior-faculty baseball game apparently resulted in more runs than could be accurately counted. Some said the score was 15-14 in favor of the seniors; others put it at 49-39 for the faculty. On Tuesday an open house, which included tours of the hydraulic testing plant at Chaffins—now Alden Research Laboratories—and the electrical engineering building—later renamed Atwater Kent Laboratories—was followed by an afternoon lawn tennis tournament.

On Tuesday evening Alfred Flinn of the Class of 1893 gave the annual Sigma Xi lecture. He talked about the engineering achievements of the city of New York. Finally, on Thursday, the graduation exercises themselves got under way. The ceremony started at 10:30 a.m. in Tuckerman Hall in the Women's Club building on Salisbury Street. The speaker was Hollis' friend and colleague, Mortimer E. Cooley, dean of engineering at the University of Michigan.

Commencement has unfolded in many venues over the years. The chapel on the third floor of Boynton Hall was the site of many early graduation ceremonies.

The annual Alumni Dinner was set for 2 p.m. that day in the electrical engineering building, but according to an account in the *WPI Journal,* the festivities began late and many guests had to run to catch their trains before all of the awards were handed out and the speeches completed.

While Commencement followed a similar formula for decades, the venue for the graduation ceremony was moved from time to time as new campus facilities were added and as the size of the graduating classes grew. The locales included Boynton Hall, Mechanics Hall, the YMCA hall on Elm Street, the electrical engineering building (when it opened in 1907), Tuckerman Hall, Alumni Gymnasium, Alden Memorial Hall, the Worcester Memorial Auditorium and Harrington Auditorium. On only three occasions has Commencement been held outdoors on the Quadrangle—in 1959, 1989 and 1990.

Since Commencement brings together on the WPI campus trustees, alumni and other dignitaries, the Institute has, from time to time, combined the annual ceremony with events ranging from anniversaries to ground breakings to build-

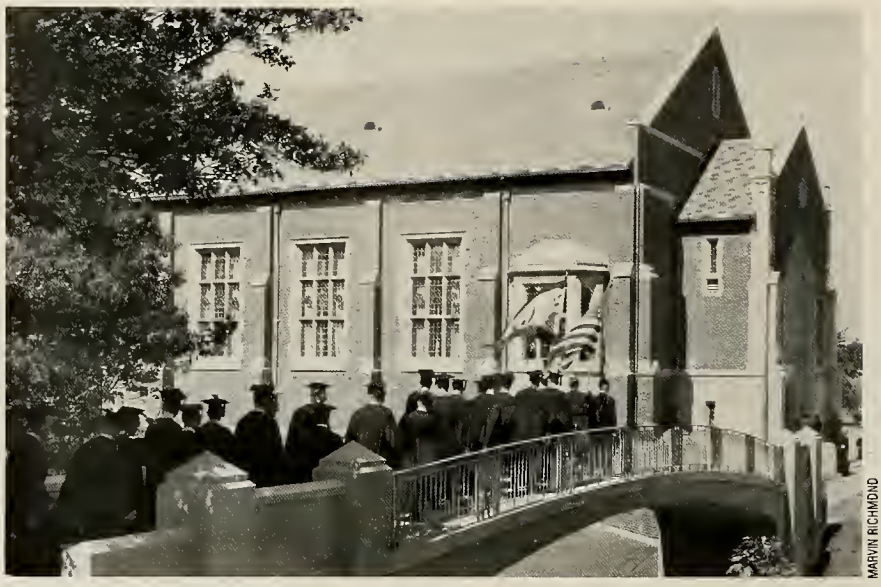
ing dedications. During WPI's 50th anniversary year in 1915, for example, Commencement week was highlighted by the dedication of the gates to Alumni Field. A procession of faculty, seniors and delegates from other colleges dressed in academic garb and marched with alumni from Boynton Hall to the gates.

At the head of the procession was marshal Zelotes W. Coombs, professor of modern languages since 1890. Edward F. Miner, president of the Class of 1887, presented the class gift—the entrance, gates and the land on which they stood—to Charles G. Washburn, president of the Corporation. The title to the field itself was presented by George I. Rockwood on behalf of the alumni. Senior class president Robert Russell made a surprise presentation, delivering 50 long-stemmed red roses to Prof. Coombs for his 50th birthday.

After the presentations, the gates were opened and guests sat in the bleachers to watch a baseball game between WPI and the Massachusetts Agricultural College—Mass Aggie won 8-1. Later in the week, after Commencement, alumni gathered once again, this time to celebrate the laying of the cornerstone for Alumni Gymnasium, a facility built in large part with alumni contributions. Among the items placed in the cornerstone were the college catalog, copies of the *Journal*, the 1915 Annual Report, a colored view of Alumni Field, and a variety of newspaper accounts and programs from the 50th anniversary celebration. The following year the new gym would host Commencement.

In 1926, immediately after the Commencement ceremony, the crowd gathered at the site of WPI's first true residence hall. (For nine years an off-campus house had been used as a dormitory.) Conrad Milton Riley, youngest son of Sanford Riley, turned the first spadeful of earth at the site of the building that would bear his father's name. Later in the day Henry J. Fuller, Class of 1895, dedicated the new pool he had donated for the 10-year-old Alumni Gym. The final event of the day was the unveiling of a tablet in Boynton Hall honoring the memory of Thomas C. Mendenhall, WPI's third president.

In 1940 WPI celebrated its 75th anniversary and its 70th Commencement. The graduation exercises were held in the new Alden Memorial Auditorium. This facility fulfilled President Earle's dream of constructing the most beautiful college building in New England on the WPI campus. Earle did not live to see Alden completed, nor was he able to see the graduating seniors march over the brand new Earle Bridge—the first official use of the footbridge that spans West Street between Boynton Hall and Alden—in a tradition still carried on today.



MARVIN RICHMOND

The class of 1940 marches over Earle Bridge to Alden Hall (top). The Class of 1950 held its baccalaureate service in the First Baptist Church (left). Norwegian students Birger D. Lund (on the left) and Per Roed graduated in 1948.

It was during Earle's presidency that the college inaugurated "Alumni Day," the predecessor of Reunion weekend, which was held the day after Commencement. The dedication of Higgins Laboratories took place on Alumni Day in 1942. The new mechanical engineering building was named for Milton Prince Higgins, the first superintendent of the Washburn Shops. During the dedication ceremony Higgins' son, John Woodman Higgins, reminisced about playing in the family horse barn in the days when "these grounds were cow pastures."

During World War II, WPI participated in the Navy's V-12 program, training 767 naval officer candidates over the course of three years. Students during those war years attended classes year-round and graduated in three years. Because of this accelerated cycle, WPI held an extra Commencement in 1944 and 1946. That is why in 1990, the 120th

JANET WOODCOCK

Joseph J. Hearne, Class of 1947, presides over the class tree ceremony. The sun shone on Commencement in 1989, one of three graduations held outdoors.

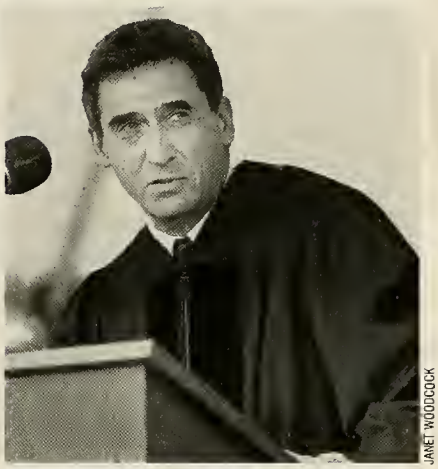
consecutive year that WPI has awarded degrees, the college celebrated its 122nd Commencement.

During the administration of Harry P. Storke the campus underwent a great expansion. Guests at Alumni Days during the 1960s saw the dedication of Daniels Hall (1963), the college's third residence hall, and Goddard Hall (1965), the chemistry and chemical engineering building, as well as the groundbreaking for Harrington Auditorium (1965).

In 1972 Commencement and Alumni Day were turned into separate events with a week between them. Commencement was shortened to a one-day affair, while Alumni Day grew into a weekend celebration.

In 1988 the college tried to hold the Commencement exercises outdoors on the Quadrangle, but as had happened for so many WPI celebrations over the years, the weather did not cooperate, and 3,200 students, parents, faculty and trustees once again packed Harrington Auditorium. The overflow audience was able to watch the exercises on closed-circuit television in Alden. In 1989 the sun shone on Commencement day and for the first time in 30 years WPI's graduation was held outdoors. A crowd of 4,000 gathered on the Quadrangle under cloudless skies to see 825 diplomas awarded.

In 1989 the tradition of the baccalaureate service, which had been abandoned in the 1970s, was restored. Another, more informal tradition continued that year. The speaker, Ralph Gomory, senior vice president at IBM, became president of the Alfred P. Sloan Foundation three days after Commencement. His two predecessors had also received timely promotions. The day before Commencement in 1987 Robert C. Stempel '55 became president of General Motors. (He is now chairman-elect.) In 1988 Leo J. Thomas became vice chairman of Sterling Drug Company shortly before the ceremony.



JANET WOODCOCK

Ralph Gomory, the 1989 speaker.

Stempel, Thomas and Gomory were also the first speakers chosen in conjunction with a Commencement theme. For Stempel it was "The Manufacturing and Productivity Imperative"; for Thomas it was "Tomorrow's Industry: Where Biology and Engineering Merge"; and for Gomory it was "The Information Age: Its Implications for Higher Education."

This year Commencement came just nine days after the college observed its 125th anniversary. The theme, "WPI in the World," was the departure point for WPI's 122nd Commencement speaker, Lester C. Thurow, dean of the Sloan School of Management at MIT.

One tradition has remained constant since the first Commencement in 1871. Each year the speaker reminds the graduates of the knowledge they have acquired and bids them to go off into the world to use it wisely. Ralph Gomory, speaking in 1989, may have said it best when he told the graduates that knowledge "puts tools into your hands, which you can use in the complex activities of real life. And with these tools, you can make a difference."

The Trailblazer and the Goat Keeper

The story of WPI's first two Japanese alumni, who returned home and forged distinguished careers in industry.

By Roger N. Perry Jr. '45

The records of the WPI Alumni Association chronicle the remarkable achievements of WPI's graduates, beginning with the earliest classes. As inventors, designers, production experts, entrepreneurs, managers and presidents of companies large and small, these alumni helped drive the industrial revolution that changed the American way of life forever.

Scattered among those early classes were a few students who traveled halfway around the world and overcame the barriers of language and culture to earn their WPI degrees. When they returned to Europe, to Asia, or to South America, their educations helped them make indelible changes in the traditional ways of their native countries.

Japan's Kotaro Shimomura, one of four foreign students representing 10 percent of the Class of 1888, was such a man. A year after he earned his degree in chemistry, his countryman Gompei Kuwada entered WPI with the Class of 1893 to study mechanical engineering. Shimomura and Kuwada were among the first of WPI's international students, but in many ways their stories are typical of those who followed.

NEW EVIDENCE OF EVOLUTION FROM VEGETABLE TO ANIMAL.

Coming to America must surely have been a cultural shock to young Kotaro Shimomura. The United States was a young country, having only recently celebrated the centennial of its founding. The West was still untamed territory and in the East, cities and industries were growing as rapidly as the flow of immigrants from Europe could help build them. The people of America were fiercely independent. They spoke their minds freely and bowed to no one.

In contrast, Japan's culture, language, social customs and politics were developed and formalized over more than 2,500 years. Until 1854, when U.S. Commodore Matthew C. Perry negotiated a trade treaty with Japan, the country was closed to foreigners. Shimomura was among the first generation of Japanese in many centuries who were free to learn about the world outside this island empire. He was, in fact, a trailblazer—among the first Japanese to study abroad.

Shimomura accepted this challenge, no doubt considering it a great honor to represent his country and his family. During his years in Worcester the Institute underwent some important changes. It changed its name to Worcester Polytechnic Institute, and began construction on its third building—Salisbury Laboratories—where chemistry students would, at last, have adequate laboratory space for their studies.

On his return to Japan, Shimomura took charge of the Harris School of Science in Kyoto, teaching there as professor of chemistry for six years. In 1896 he went to Belgium, where he spent a year studying by-product coke ovens. Back in Japan he was instrumental in forming the Osaka Seimi Works Company, which built Japan's first by-product ovens in 1897.

Hired as chief engineer of the company, he was soon promoted to managing director and later became president. He served in that capacity until 1926, when the company was amalgamated with the Osaka Gas Company. He was at that time already connected with the latter company as a director and consulting engineer. After the merger, he became managing director.

He founded the Oriental Wood Preservative Company and served as its president. He later wrote that he was inspired to form the company in 1907 after returning to Japan following a second trip to Belgium. There he supervised the con-

Kotaro Shimomura (above) paved the way for other WPI students from Japan, including Gompei Kuwada (below). At left, one of Kuwada's drawings.

struction and start-up of 100 Semt-Solvay Ovens at the Government Steel Works, and observed the tar oils produced by the operation of the furnaces.

The Japanese government drew on Shimomura's expertise in technical matters when the outbreak of World War I cut off imports of foreign dyestuffs. He was asked to organize, construct and begin manufacturing in the government-subsidized Japan Dyestuff Company in Osaka. In recognition of this contribution, the government bestowed on him the title of Doctor of Science in 1915.

In a 1926 letter to WPI Alumni Secretary Herbert Taylor summarizing his career, Shimomura modestly mentioned that the Emperor had recently decorated him with the "Indigo" Order of Merit for technical services in industry. WPI also paid tribute to Shimomura's distinguished career. On the occasion of the 45th reunion of the Class of 1888 in 1933, the college conferred on him the honorary degree of Doctor of Science.

Gompei Kuwada was preparing for WPI at Northampton High School in Massachusetts as Shimomura was earning his WPI degree. Although they were on campus at different times, it is possible that they knew each other during that period. Later in life they did become close friends and business colleagues.

The 1893 yearbook notes that by the time of his graduation "Gumpy" had mastered the Yankee joke with all its subtleties. He was a popular member of one of the Institute's more distinguished early classes. A charter member of the local chapter of Sigma Alpha Epsilon fraternity, Kuwada was also the class's official mascot bearer—it was his responsibility to parade a goat at all class and school functions. Legend has it that Kuwada acquired his title because his initials could have doubled for "Goat Keeper."

Among the verses which parodied a then-popular song in the 1893 yearbook was the following:

"We have a chap from Tokyo,
Who's full of fun from head to toe.
He kills the profs with questions queer.
Which makes us smile from ear to ear.
He brought the Goat for 'Ninety-Three,'
And had it kept without a fee.
In spite of this, he did confess,
'I think it can be done for less.' "

Kuwada, considered the best artist in his class at a time when freehand drawing was still a required subject, contributed much of the artwork for the yearbook.

In a letter to Herbert Taylor in early 1941, Kuwada, then retired, reminisced about his class, which was looking forward to its 50th reunion. He wrote, "If you think my classmates may like to know what has become of their old 'goat keeper' you may put this in your journal's spare space. What appears in print about one's self is often so twisted up that one hardly believes it to be one's self. So here goes a true story."

Kuwada went on to provide a lengthy summary of his life and career. After graduation he returned home and became a mechanical engineer in the military arsenal of Osaka. After nine years there he took a job as the manager of the machine shops at Kawasaki Dockyard Company in Kobe. Eight more years passed and then he retired briefly to a seaside villa, before a call from Kotaro

One of many scenes of natural beauty drawn by Kuwada for his yearbook (top). Kuwada in later life (below).

Shimomura brought him back into the world of engineering.

Shimomura asked Kuwada to take charge of the mechanical side of the Osaka Gas Company's business. While there he supervised the construction of the Japan Dyestuff Company. Finally, tired of working for other people, he started a small company, making spindles for textile mills. Until then, he wrote, "all such machine parts had been imported and it was just about that time that the European War had cut off foreign supplies and not a single spindle could be imported."

While it turned out that running a business meant "working for other people more than ever," he stayed at it for 22 years, eventually producing spindles for 60 percent of the spinning mills in Japan. He increased the company's production rate from a few hundred spindles to nearly 200,000 per month and expanded its product line. Finally, the demands on his company for new types of products outstripped its capabilities.

"Moreover," he wrote, referring to himself in third person, "being within an ace of 'three score and ten,' he followed the words of the Good Book and resigned from the duties as president of the company. . . . The company was ultimately acquired by a larger firm. Thus ended his war," Kuwada wrote, "and like Humpty Dumpty he is 'no more.' "

After his retirement he studied herbs in the Kyoto botanical gardens and assisted professors at Osaka University in medical research, an interest prompted, he noted, by his upbringing in a family with several generations of doctors.

In summary, he wrote that his 47 years of work [were] "very interesting, as these years passed through the period of mechanical and industrial expansion and through the stresses of several wars. . . ."

What Kuwada omitted was the fact that WPI, in 1928, awarded him the honorary degree of Doctor of Engineering. That same year, at his 35th Reunion, the old goat keeper was present to see a tradition of his undergraduate years revived. The class had commissioned the creation of a bronze replica of a goat's head attached to an abnormally small body. This was presented to the college as the trophy for the traditional freshman-sophomore competition.

Kuwada's son and only child, Suyenori Kuwada, entered WPI with the Class of 1930, but became ill and died while still a student. In his letter to Herbert Taylor, Kuwada included a personal postscript: "It avails none to count the age of one's children passed away, but when I see the figure of so many young undergraduates as depicted in the *Journal*, I think of him also grown up and recall with deep gratitude the great kindness that the boy's good friends of America had shown him during his period of study at The Tech and during his distress. Such thoughts lead to mutual understanding, which, if attentively cared for, should not throw nations into war."

But such mutual understanding between Japan and the U.S. was not to be. As Kuwada was looking forward to WPI's 1943 Reunion, the events surrounding World War II made mortal enemies of the two countries he held dear. Kuwada's last personal contact with someone from WPI was in 1947. Frank Harding '50 had often heard his late grandfather, John P. Coghlin, speak of his Japanese classmate. While serving in the U.S. Army of Occupation in Japan, Harding and Sumner Herman '50 searched out Kuwada.

"We had his address from the WPI Alumni Office and we set out by train from Tokyo to Kyoto," remembered Harding. "He lived in a very traditional Japanese house, the kind I'd always imagined as a kid growing up. It had suffered no damage during the war. About the only nontraditional feature was a black lacquered, Western-style dining room set of table and chairs. He was very proud of this."

The two WPI graduates were welcomed by Kuwada and his wife and enjoyed an amiable and polite conversation. Kuwada showed the visitors a lantern with a square hole set up near a pond in his traditional Japanese garden. "He explained that there was a festival each fall in which fires were burned in a particular pattern on a mountainside 20 miles away. When that happened, the light from the fires shone through the square hole and reflected on the surface of the pond.

"Although our visit was brief, he seemed pleased that we had come. He was clearly proud of Worcester Tech and his association with the college. He expressed the hope that a spirit of friendship would grow between Japan and the United States in the aftermath of the war."

The final chapter in this story of WPI's first two Japanese students is but three sentences long. It came in a letter to WPI from Akira Shimomura, dated September 16, 1949. "I regret to inform you that your alumnus Dr. Gompei Kuwada passed away on the 13th of September at the age of about 80. He is survived by his wife—no children. Dr. Kuwada was a very good friend of my deceased father, Dr. Kotaro Shimomura, who died 12 years ago."

Perry is editor of Quest, *the newsletter of the* Campaign for Excellence.

Timeline

A Journey Through WPI's First 125 Years

By Neil Norum

Second of Four Parts—The Late 1920s

Robert Goddard '08 launched this liquid-fueled rocket in Auburn, Mass., in 1926.

It was the period between the wars, the time of Gertrude Stein's "Lost Generation." The magazine *International Affairs* described the 1920s as the "Period of Fulfillment," but most Americans remember those years as the Roaring '20s—full of fads, fashions and flappers. The decade was ushered in by Prohibition, which triggered an era of illicit liquor trade and gang warfare. In 1929 Al Capone's gang "rubbed out" six rival gang members in Chicago's St. Valentine's Day massacre.

In 1927 *The Jazz Singer* heralded the arrival of talking pictures. Two years later 9,000 of the nation's 20,500 movie houses had sound and the age of silent movies was all but over. Another new era in film was launched in 1928 when George Eastman demonstrated the first color motion picture film. The Marx Brothers and Greta Garbo were popular screen stars and Broadway fans were enjoying such musicals as *Broadway Melody* and *Desert Song*.

It was a golden age in literature, with Ernest Hemingway's *A Farewell to Arms*, William Faulkner's *The Sound and the Fury*, Thomas Wolfe's *Look Homeward, Angel* and Erich Maria Remarque's *All Quiet on the Western Front* appearing in stores in 1929. Highlights in music included George Gershwin's "An American in Paris" and Maurice Ravel's "Bolero," both of which premiered in 1928, and Toscanini's appointment as conductor of the New York Philharmonic.

Having built 15 million Model T "Tin Lizzies," Ford introduced its successor in 1927, the Model A, which featured shock absorbers, a speedometer and more

graceful lines. That year Sacco and Vanzetti were executed and Lizzie Borden became the prime suspect in the murder of her parents in Fall River, Mass.

Sports fans were talking about Gene Tunney, who retained his heavyweight boxing title by defeating Jack Dempsey after a controversial long count in 1926, and Babe Ruth, who hit 60 home runs in 1927. Buck Rogers made his first appearance in the comic pages in 1929, the same year Hoagy Carmichael composed "Star Dust," Mickey Mouse and Popeye made their debut, Isadora Duncan met her untimely end, and Billy Sunday made news preaching at revivals.

Among the major developments in science were Albert Einstein's announcement that he had found the key to formulating a unified field theory, Alexander Fleming's discovery of penicillin and Henrik Dam's discovery of vitamin K. The late 1920s was also a time of great engineering achievements. The Holland Tunnel between New York and New Jersey, the Moffat Tunnel through the Rocky Mountains and the Cascade Tunnel—the longest railroad tunnel in North America—were completed. Construction was started on the Empire State Building, and the iron lung, the quartz clock and

The 1920s saw the rise of the Air Age. Charles Lindbergh made his historic crossing of the Atlantic in 1927, the same year that WPI launched a new course in aeronautical engineering under the direction of Prof. Kenneth Merriam, shown seated in the foreground in the top photograph. Among the state-of-the-art tools in the college's aero lab was a Navy monoplane with a 52-foot wingspan.

the teletypewriter were introduced.

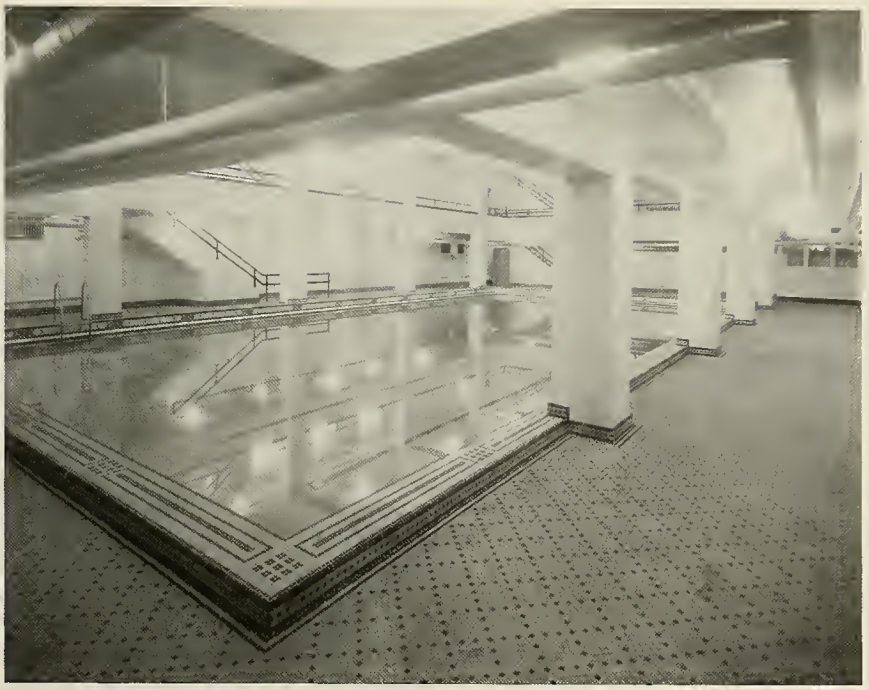
In 1928 the first scheduled television broadcast was made from station WGY in Schenectady, N.Y. The following year Bell Laboratories demonstrated color television, successfully transmitting images of the American flag, the Union Jack and a bouquet of roses. Following a demonstration of television technology by Westinghouse Electric Company in 1928, Harry P. Davis, Class of 1890, chairman of the board for the National Broadcasting Company, said, "The time is not far distant when the use of television will be as commonplace as the present use of radio receivers."

By 1929, 20 million telephones were in use in the United States, nearly twice the number installed throughout the rest of the world. Americans were paying a minimum of $118 for a console model radio made by Atwater Kent of WPI's Class of 1900, which they used to listen to *Amos 'n Andy,* Rudy Vallee and Graham MacNamee's broadcasts on NBC radio.

A WPI graduate was also making far-reaching contributions to science and technology. Robert Goddard '08 was well along in his quest to develop a working liquid-fueled rocket. "During the summer he conducted a test of his latest model at a point near Worcester," the *WPI Journal* reported. "The noise of the resulting explosion terrified the natives for miles around and started fantastic stories about the failure of the experiment. Dr. Goddard calmly assured press representatives that the test had been 'quite successful,' and he is a scholar who knows the meaning of 'quite.' "

Interest in aviation was growing in the late 1920s, due in no small measure to Charles Lindbergh's nonstop solo flight across the Atlantic in 1927, the first round-the-world flight by the Graf Zeppelin, the adventures of Amelia Earhart and Richard Byrd, and the exploits of barnstormers, who brought the excitement of flying to every corner of the country. Commercial airlines flew 30 million miles in 1929, up from six million miles in 1927, and they carried 180,000 passengers. That year a film about pilots and flying, *Wings*, won the first Academy Award for best picture.

At WPI a new course in aeronautical engineering, open to a select group of senior mechanical engineers, was introduced in the fall of 1927 under the direction of Prof. Kenneth Merriam. A laboratory, complete with a Navy monoplane with a 52-foot wingspan, was set up on the top floor of the Washburn Shops.



President Ralph Earle (at right with 1938 Commencement speaker William Durand, noted Stanford University aeronautics engineer) set in motion a period of change at WPI. One welcome addition was the new Fuller Swimming Pool.

The end of the decade brought the beginning of the Great Depression, triggered by the disastrous stock market crash in October 1929. That year 71 percent of U.S. families had incomes below $2,500, considered then the minimum necessary for a decent standard of living. The average weekly wage was $28. At WPI, department heads were earning $4,500 to $5,000 per year, while salaries for faculty members ranged from $3,500 to $4,500 for full professors to $1,800 to $2,400 for instructors.

WPI did not truly feel the effects of the Depression for a few years. "The financial problems of the college during the six-year period of national distress were never acute," noted Herbert Taylor in *Seventy Years of the Worcester Polytechnic Institute*. "Retrenchments were necessary. Very little money was available for new equipment or even for ordinary maintenance. Some retiring teachers were not replaced, but at no time was there a reduction in salaries of the staff."

Ralph Earle became WPI president in 1925 (he would serve until his death in 1939) and promptly announced five key objectives for the years ahead: increasing enrollment, improving the campus, completing a new swimming pool, constructing a residence hall for freshmen (the college's first) and finding new markets for the products of the Washburn Shops.

The $30,000 swimming pool was completed the following June, thanks, in

Clockwise from top left: Sanford Riley Hall shortly after its completion; a replica of "The Thinker," an award for academic excellence for which fraternities competed; the experimental trolley car in its bay in Atwater Kent Laboratories; class rivalries acted out then, as now, with the annual rope pull; a track meet on the college's still young Alumni Field; a typical WPI student of the late 1920s.

part, to the generosity of Henry J. Fuller of the Class of 1895 and his partner, John E. Aldred. The new residence hall, named for trustee R. Sanford Riley, Class of 1896, who died in 1926, was ready for occupancy by 115 freshmen a few months later. It boasted two Atwater Kent radio sets, a cleaning and laundry service, and a hydraulic elevator.

In 1926 Earle moved to revive chapel exercises, in keeping with John Boynton's original wishes. The voluntary 10-minute morning service, led by local ministers, teachers and businessmen, was popular with students. With the chapel fulfilling its original function once again, Earle decided to raise some funds to redecorate and refurnish it.

Recalling the story of how students from the classes of 1885 and 1886 brought Milton Higgins' horse "Buckskin" to the third-floor chapel one night, he wrote to those alumni and suggested they might make amends for the damage their schoolboy prank had caused. The classes contributed $5,000 and the refurbished chapel was rededicated as Sinclair Hall in memory of John E. Sinclair, the professor who had rescued the students from suspension.

The chapel's appearance was improved still further with a gift from the Class of 1930: six stained glass medallions for the larger windows depicting the seals of the United States and Massachusetts, and the tools of mechanical, civil, electrical and chemical engineering.

Two new programs were introduced at WPI in the mid-1920s. A monthly lecture series proposed by Homer J. Fuller, Class of 1895, was launched in late 1925 to give students an opportunity to hear men of outstanding achievement.

The first speaker was Edward B. Craft, vice president of Bell Telephone Laboratories. And Freshman Week, described by the *Journal* as "two days of intensive instruction on how to be a Tech man," was started in 1926.

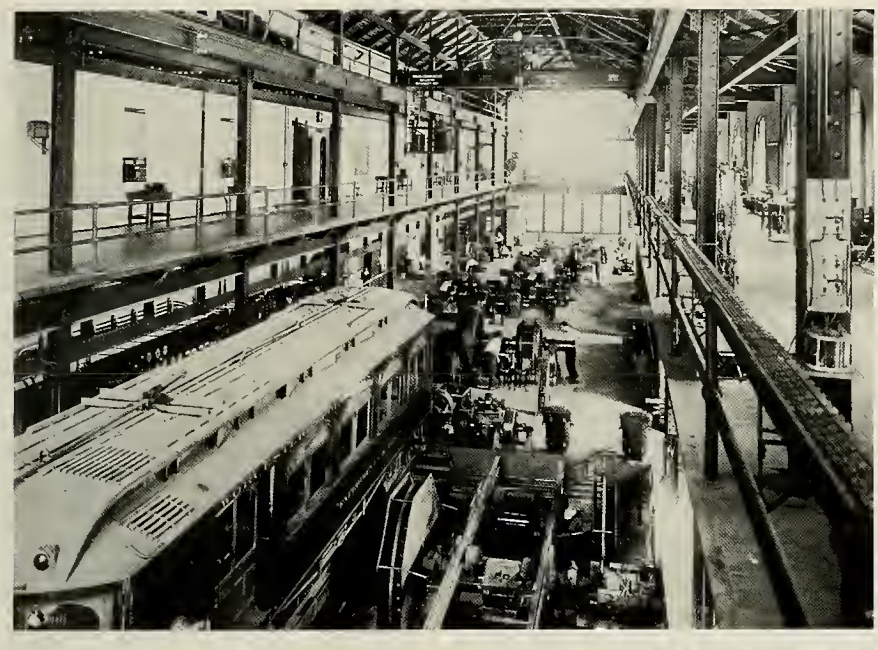
The first Freshman Week included talks on physical education and the "Aim of Engineering Education"; meetings with advisors; registration; placement exams in mathematics and modern languages; and lectures on fraternities, the business of being a college student, time planning, and Institute rules and customs.

"At Home Day" took place in May 1929. Parents of undergraduates and prospective students, as well as alumni, teachers and high school boys, came by the hundreds for "an all-round opportunity to see what is doing on Boynton," reported the *Journal*.

The first Class of 1879 Award for rhetoric was presented to senior Warren Purcell '30 for his essay on "The Scientific Development of Sound Motion Pictures." Since 1915 fraternities had competed for possession of a replica of Rodin's "The Thinker," given to the house that achieved the highest academic average. George F. Fuller did that one better by establishing a $250 academic award for fraternities.

Undergraduate enrollment rose steadily during the 1920s, increasing from 522 in 1925 to 681 by 1931. Large entering classes in 1929, 1930 and 1931 led to crowded conditions in classrooms and laboratories. In response, the faculty developed a plan for selective admissions that would restrict freshmen classes to 150. While the plan was never fully implemented, increases in tuition did ultimately help put a cap on the size of entering classes. From $230 in 1925, tuition rose to $280 in 1928 and to $330 in 1932.

Of the 205 members of the Class of 1929, 49 were from Worcester; 76 were from elsewhere in Massachusetts; 20 were from Connecticut; seven were from Rhode Island; five were from New Hampshire; and the remainder were from



Maine, New Jersey, Pennsylvania, Canada and Russia. "They are no worse than the average," the *Journal* noted.

Demand for the Institute's graduates remained steady in the 1920s. Noted the *Journal* in 1929, "A larger number of industries than ever are sending representatives to interview seniors. A slight preference is indicated for mechanical engineers. Salaries offered range from $120 to $180 per month, with a median of $130." One graduate of the era, Richard K. Irons '27, became WPI's first Rhodes scholar in 1928.

Many WPI graduates were hired by the chemical industry, which made spectacular gains during the 1920s, especially in the manufacture of plastics, dyes and synthetic fibers. Manufacturers of electrical equipment also enjoyed a boom as the value of heavy household appliances rose from $109 million in 1919 to $268 million in 1929.

A WPI landmark disappeared at the end of 1928 when the college's experimental trolley car was dismantled, a "result of rapid changes in the field of transportation," the *WPI Journal* noted. No visitor to the college was considered properly entertained unless he had inspected it, one writer sadly commented. The test car, in use since 1907, had ventured out of the electrical engineering building to travel virtually every street railway and interurban line in New England. Nearly 3,900 miles of track were tested at a cost to rail companies of $3.60 per mile.

Something else disappeared shortly thereafter: the gilded hands from the Boynton Hall clock. The hands had last been stolen in 1893. This time the *Tech News* observed the theft with the following short poem:

> That the sport they'd had was rare
> At recitation could be late
> And be quite sure of easy fate
> For without the hand to show
> They couldn't tell the time you know.

Herbert Taylor aptly summed up where WPI stood at the end of the 1920s. "Some day the full account of these years will be written . . .," he noted. "The appraisal of President Ralph Earle, his colleagues and his times, will constitute a bright chapter in the long history of the Worcester Polytechnic Institute, an excellent engineering college that would not stay within the bounds of its founders' vision."

A New Jewel on Campus

To celebrate its 125th birthday, WPI recently dedicated its newest building.

By Michael W. Dorsey

From its computer-packed laboratories to its state-of-the-art lecture hall to its computer-controlled energy management system, The George F. Fuller Laboratories, named for the former chairman of Wyman-Gordon Company and longtime WPI trustee, is a showcase of modern technology. With its translucent skylight, its four-story, light-filled atrium and its sleek glass-enclosed lounge and conference rooms, it is also a striking example of modern architectural design.

The information sciences building, the first new academic building constructed at WPI since 1966, is home to the Computer Science Department, the College Computer Center, the Office of Academic Computing and the Instructional Media Center.

On approaching Fuller Labs, one notices first of all how easily it fits into its unusual site. Its five floors cascade gracefully down a steep hillside on the northeast corner of the campus. To build the foundation for this unusual structure, workmen poured more than 3,700 cubic yards of concrete.

The red brick facing echoes the facades of Fuller's three companion structures: Atwater Kent Laboratories, Kaven Hall and Salisbury Laboratories. Concrete walkways traverse the hillside beside the building and lead to a spacious bluestone plaza named for P. Warren Keating '40 and Paul J. Keating '64, whose company provided at cost the structural concrete for the building.

From overhead, the building, designed by the Boston-based firm of Payette Associates, is dominated by a 176-foot skylight. Made from acrylic resin, the skylight stretches between the stately two-story entrance at the southwestern end and the dramatic, four-story entryway at the northeastern end at Salisbury Street. Inside, the triangular skylight gives a bright, airy feel to the building's central spine.

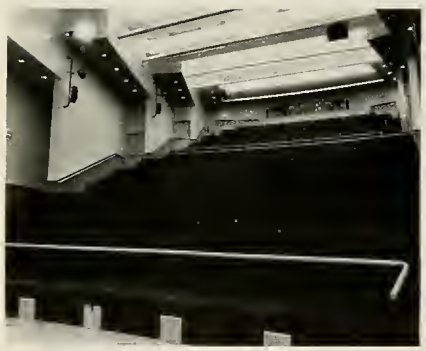
The spine connects the building's three main sections—an office wing, a computer and laboratory wing and a 400-seat lecture hall. At the Salisbury Street end, the spine projects some 40 feet beyond the building proper, forming a glass-enclosed tower that contains a spacious student lounge and two conference rooms. Fuller's topmost floor, level three, contains two general purpose classrooms and six computer science research laboratories. One lab is set aside for work by graduate students and another is available to undergraduates for specialized project work.

On level two is the College Computer Center, whose facilities include a central computer room containing mainframe computer systems and high-speed laser printers that are linked by a high-speed data network to every office, classroom and laboratory on campus. Nearby, programmers work in built-in cubicles in a room accented by a large bay window.

At Fuller's southernmost corner is the General Access Workstation Laboratory. Its powerful engineering workstations are available to students 24 hours a day. At the opposite corner of the building on the same level are the administrative offices of the Computer Science Department and offices for about half of the department's 13 faculty members and graduate students. (The remaining faculty members and students have offices on level one.) A library provides a quiet corner for reviewing the latest professional journals. A 16-chair conference room on this level is available to all members of the campus community.

Doorways on level two (and on two other floors) provide access to the Perreault Lecture Hall, named for Raymond J. Perreault '38, president of Falls Machine Screw Company, and his wife, Ina.

Fuller Lab's central spine (right) projects beyond the building (above) to form a dramatic, glass-enclosed tower housing a lounge and conference rooms.



(1) The larger of three conference rooms; (2) the Perreault Lecture Hall; (3) the television studio; (4) the main computer room; (5) the General Access Workstation Laboratory; (6) the College Computer Center reception area.

The lecture hall, the largest on the WPI campus, is equipped with a host of sophisticated audiovisual equipment. The facilities include two projectors capable of showing 35- and 70-millimeter Dolby stereo films. WPI is one of a handful of U.S. colleges with this capability.

The hall has a sophisticated seven-speaker sound system with a computer-controlled patch bay that can instantly interconnect the components in any combination. A preparation room adjacent to the stage includes lab benches and a sink where instructors can ready lab demonstrations. The demonstrations themselves can be carried out in the lecture hall on a cart equipped with running water, propane gas and a vacuum source.

With a state-of-the-art projection system, instructors can give students a close look at visual aids. A specially designed cart includes video versions of slide and overhead projectors, as well as a videocassette player and a personal computer. The output from any of the devices can be displayed on a video projector at the front of the hall and on two other projectors that are hung from the ceiling.

The lecture hall's equipment is maintained by the Instructional Media Center, headquartered on level one. The IMC also operates an instructional television studio with a 49-seat classroom where lectures for WPI's satellite educational programs are taped. The programs enable students to work toward their degrees by "attending" lectures at off-campus locations.

The studio and adjacent production control room and master control room, equipped with video recording and tape editing equipment, are available to the campus community for producing a wide range of educational programs. From the master control room the IMC also operates a campuswide video bulletin board and can record events taking place at remote facilities around the campus.

Also on level one are offices for the IMC staff, facilities for graphic arts production and darkroom work, additional space for the CCC programming staff and a six-seat conference room. On the

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5

6

basement level are laboratories equipped with workstations and powerful personal computers, where students learn about programming and computer organization. A general purpose computer lab is available to undergraduates completing project work.

Also on the basement level are the Office of Academic Computing, which provides hardware and software support for WPI's 1,000 personal computers, and the office of the vice president for information systems and services, who oversees all of the college's computer operations. The OAC's facilities include a repair shop and a general access personal computer lab. In the subbasement are a machine room containing the Computer Science Department's larger computers, an instructional laboratory in computer operating systems, a computer graphics research laboratory and building support facilities.

Because computers are extremely sensitive to heat and moisture, Fuller has a computer-controlled climate management system that carefully regulates its temperature and humidity. The building also has a sophisticated power distribution system that provides each office and lab with room power and "clean" power—special electric service designated for computers and other electronic equipment.

Electric cables make up part of the more than 30 miles of wire and cable in Fuller. Traveling along those miles of wire at the speed of light are billions of bits of information. Fuller Laboratories, in fact, is dedicated to the science of gathering, processing and disseminating information. By building a state-of-the-art home for the information sciences, WPI is doing more than acknowledging the profound impact that the Information Age's technology and techniques will have on all areas of science, engineering and management. As did the men who created the Institute 125 years ago, WPI is laying a foundation for the future.

Improving the AIDS Drug Approval Process

Interactive Qualifying Project by Kenneth S. James '90 and Ira H. Nydick '90.

Advisor: Ruth L. Smith, associate professor of religion.

Acquired Immune Deficiency Syndrome (AIDS) has taken a terrible toll in the United States. Between June 1981 and January 1990, a total of 121,645 Americans were diagnosed as having AIDS, 72,580 AIDS sufferers died, and between one and 1.5 million others were infected with the virus linked to AIDS, according to the National AIDS Information Clearinghouse.

The disease has stymied drug researchers because few drugs have proven effective against the AIDS virus itself, or against the opportunistic infections and tumors associated with the disease. Of the more than 140 therapies available or currently in development, only azidothymidine (AZT) has been approved to treat the virus directly. Just a handful of other drugs have been approved to fight AIDS-related illnesses.

Over the past decade a debate has ensued about the process by which the federal government evaluates and approves new AIDS drugs. Specifically, how much information does the Food and Drug Administration (FDA) need to have about a new drug before the medication can be made available to AIDS sufferers?

Some advocate applying the FDA's normal drug-testing policies to AIDS drugs, since reducing testing requirements would increase the risk of allowing a dangerous drug on the market. Others argue that because of the unusual nature of AIDS—it appears to be always fatal and the AIDS epidemic has spread at an alarming rate—the normal procedures are simply too slow. AIDS patients should

JANET WOODCOCK

James (left) and Nydick. Their project, winner of the 1989 Class of 1975 Award, proved the federal government's approach to regulating the introduction of new AIDS drugs.

be allowed to accept a higher degree of risk, they contend, if there is a chance their lives might be extended.

The FDA, which is charged with assuring that new drugs meet stringent standards for safety and effectiveness, employs a seven-step drug approval process. New drugs must undergo *in vitro* and animal studies, a series of human trials, and increasingly lengthy and wide-ranging tests that determine dosage, toxicity and efficacy.

Using a detailed questionnaire of their own design, James and Nydick first asked people with AIDS (PWAs) what they thought of that process. The students also developed a set of recommendations for improving the AIDS drug development and approval process in the United States. Their suggestions grew out of interviews with AIDS researchers, pharmaceutical company representatives, politicians and people with AIDS.

Much of the research was conducted during a two-month stay at the University of California at Los Angeles Medical School, where the study received the approval of the hospital's Institutional Review Board. James and Nydick were the first WPI students to do project work in cooperation with UCLA. Funding for the IQP came in the form of the 1989 Class of 1975 award, a competitive start-up grant given each year to members of a student project team who develop their own project plan. Among the conclusions the students reached were the following:

—PWAs are dissatisfied with the current drug development and approval process.

—The majority of the 139 individuals who returned the survey said they would choose a more promising experimental drug (even if it was potentially more toxic) over a less promising, relatively nontoxic therapy.

—While PWAs said they want greater access to new therapies, they want the FDA to continue its monitoring role.

—Withholding an experimental drug from individuals with AIDS or ARC (AIDS-related complex) can only be ethically justified if it is highly probable that not doing so would adversely affect clinical trials aimed at evaluating the effectiveness and safety of that drug or other AIDS therapies.

—The FDA should be given the space, equipment and personnel necessary to enable it to review promptly the increasing number of AIDS-related drug applications and to support its role as a facilitator of efficient drug development.

—The parallel track concept, which gives patients access to experimental drugs earlier in the approval process, may be the best compromise between withholding drugs until all tests are completed and inadvertently releasing dangerous therapies. The possibility of relieving pharmaceutical companies and the FDA from liability claims should also be investigated, the students noted.

Preventing Hazardous Waste Spills

Interactive Qualifying Project conducted at the Federal Technical Institute in Zurich, Switzerland, by Cheryl A. Pearson '90 and Stuart C. Pearson '90.

Advisor: James C. O'Shaughnessy, professor and head of the Civil Engineering Department.

The students, who spent their junior year in Switzerland, used a case study of a hazardous waste spill in that country to examine the social consequences of such disasters and to illustrate their impact on the development of new technology. The key to effectively managing such disasters, they found, is an interdisciplinary approach that involves designing and constructing facilities and equipment to prevent spills, training employees in clean-up techniques, and planning ahead so that countermeasures can be put into effect quickly and efficiently.

In November 1986 about 30 tons of hazardous chemicals were washed into the Rhine River when a Sandoz Ltd. warehouse in Schweizerhalle, Switzerland, caught fire. The fire apparently began when a blowtorch used to shrinkwrap palettes ignited paper sacks filled with dye.

The spill destroyed virtually the entire eel population of the river, as well as much of its fish and wildlife. It also polluted the atmosphere with emissions of burnt oxides of sulphur, phosphorous, nitrogen and carbon, and resulted in the shutdown of hydraulic plants in Switzerland, West Germany, France and the Netherlands. Several tons of insecticides and an estimated 100 kilograms of mercury seeped into the earth around the warehouse.

The students said the accident resulted in a loss of public confidence in the Swiss chemical industry and brought about changes in plant operation and safety. By fall 1986 Sandoz had received 962 legal claims totaling 100 million Swiss francs (about $65 million). An environmental interest group was established in Switzerland and joined with similar groups in nearby countries to protest the accident and the pollution of the Rhine in general.

Since the spill, Sandoz has changed the way it stores chemicals and responds to emergencies at its warehouses. It has increased from four to 10 the number of categories into which it places potentially risky chemicals, and it has developed a separate disaster plan for each category.

NEIL NORUM

Cheryl Pearson and Stuart Pearson with a souvenir of their year in Switzerland.

Catch basins were constructed to collect liquids sprayed on fires by fire fighters and the company eventually dropped 116 products from its chemical and agricultural products divisions. The company also set up the Sandoz Rhine Fund to finance research projects relating to the ecology of the river.

The students concluded that while a plan incorporating good organization, resources, training and planning is the surest way to reduce the impact of hazardous waste disasters, it is far better to prevent disasters by educating people about the need to protect the environment and the ways in which this can be accomplished.

Making Flying Safer

Interactive Qualifying Project completed at the Washington, D.C., Project Center by Brian J. Carpenito '90, Rob Mendelsohn '91 and Milton Venetos '91.

Advisors: Robert J. Hall, associate professor of management and director of continuing education, and William B. Miller, professor emeritus of mathematical sciences.

Sponsor: Federal Aviation Administration

With support from the FAA, Carpenito, Mendelsohn and Venetos surveyed pilots and researched midair collisions and near-midair collisions (in which two airplanes come within 500 feet of each other). In the process they uncovered some puzzling information.

More flight hours are logged in uncontrolled airspace (where formal air traffic control is not available and pilots follow visual flight rules [VFR] and use their radios to avoid accidents) than in controlled airspace. Not surprisingly, 95 percent of all midair collisions involve small aircraft and occur within five miles of uncontrolled airports. Still, more near-midair collisions (NMACs) are reported each year in controlled airspace than in uncontrolled airspace.

A survey by a 1988 WPI project team provided an answer. While 66 percent of the pilots surveyed said they had experienced an NMAC, 92 percent did not report the incident. The pilots said they are unsure about what constitutes an NMAC and worry about their liability in such incidents. In addition, no reporting system specifically tailored to near-midair collisions yet exists.

Carpenito, Mendelsohn and Venetos proposed just such a system to the FAA. It includes a postage-paid reporting form on which pilots check off the details of the NMAC and note their own opinions about the cause. While pilots are asked to include their names, addresses and telephone numbers, this information would be used only by the organization responsible for collecting the data (preferably a nongovernment organization, such as the Aircraft Owners and Pilots Association Air Safety Foundation). The students also wrote a pamphlet, "How to Report an NMAC," which would be included with each form.

Raymond T. Kelly, an air traffic control specialist with the Advanced Concepts branch of the FAA, worked with the students in Washington. Kelly says the FAA is exploring the potential application of this new NMAC-reporting system. "This report holds the possibility of contributing significantly to the much-needed database of information regarding the incidence of near-midair collisions in uncontrolled airspace," he said.

In addition to implementing their reporting system, the students recommended that the FAA train VFR pilots and student pilots in the entire NMAC reporting process. They also suggested that the FAA include reporting forms with certificates given to newly licensed pilots; take positive, less stringent enforcement action in response to NMAC reports; and incorporate reported incidents into pilot training.

—Bonnie Gelbwasser

FINAL WORD

Ed Meilus' Listeners Know "It's Best in Lithuania"

Across the United States, Lithuanian-Americans have been keeping a close watch on the news of late. Their homeland was the first Soviet republic to make a declaration calling for the restoration of its independence. And Lithuania has joined many other Soviet-controlled nations in holding free elections for the first time in 50 years. But, while Lithuanian-Americans have rejoiced at these developments, they are also watching nervously to see just how far the Soviet Union will let this Baltic nation spread its wings.

As the *Journal* went to press, the Soviet Union had reacted to the independence declaration with an embargo on supplies of oil, natural gas and other essentials. Lithuania, in turn, indicated it might put on hold laws designed to put the declaration into effect.

The 40,000 Lithuanian-Americans who live in central Massachusetts have a special place to turn to get the latest developments, including news that doesn't always appear in daily newspaper accounts. It's called "Ausra," a Lithuanian cultural program aired each week on WICN, Worcester's public radio station. The show has been hosted for the past 15 years by Eduardas Meilus Jr. '76.

The program begins each Sunday at 8 p.m. with a rousing rendition of the Lithuanian national anthem sung in native tongue. Next Meilus often shares with his listeners whatever tidbits of news he has been able to gather, including bulletins faxed to him by Lithuanian newspapers in Chicago and Cleveland. (Both cities have large Lithuanian communities.)

"An hour just isn't enough time to give all the news and information about what's happening in Lithuania today," Meilus recently told a local newspaper reporter. "The news changes so fast that sometimes I get behind. I'll read something over the air and get a call from a listener saying, 'Didn't you hear what happened this afternoon?' "

Meilus' listeners are a loyal group, something they demonstrate each time member-supported WICN mounts a fund-raising drive. During the most recent drive the station raised more than $1,500 while "Ausra" was on the air. "When you generate that kind of revenue in Worcester, you know you've got a loyal audience in that time slot," reported Gene Petit, WICN program director.

Until the recent wave of democracy rolled across the Soviet Bloc, Meilus says his audience consisted mostly of older listeners who like to hear traditional Lithuanian songs. Lately, he says, "Ausra" has become an important source of news for younger listeners, who want to hear about the activities of the grassroots group Sajudis, which is spearheading the movement to separate from the Soviet Union.

According to Meilus, the Sajudis movement aims to restore Lithuania to independence, a state it has enjoyed for just 20 of the last 195 years. A thriving kingdom established in 1251, Lithuania was absorbed into a Polish commonwealth in the 1500s and fell under czarist rule in 1795. In 1920 Lenin recognized the nation's sovereignty, but the so-called nonaggression pact between Germany and Russia returned Lithuania to the Soviet sphere of influence in 1939.

Despite the changing listener profile, Meilus says he has not tinkered with the show's traditional format. He still introduces the show each week with a thematic talk in English, designed, he says, to hold on to listeners who stay tuned after the previous program ends. He then mixes traditional music with news, which he delivers fluently in either English or Lithuanian.

"Lithuania has a small contemporary music scene," says Meilus, "but I like to play the old tunes." Even in these traditional songs, national freedom is a common theme. One popular number is the melancholy "Neverkite Kankles" (Don't Cry, Zithers).

Usually associated with India, the zither is Lithuania's national instrument. The zither is not the only link between the two countries, notes Meilus. Linguists have discovered that modern Lithuanian, like some Indian dialects, is descended from primeval Sanskrit. Meilus, who speaks French, German and Swedish, as well as English and Lithuanian, says the Lithuanian words for "father," "mother," "sun," "moon," "god" and "love" are identical to primeval Sanskrit.

A native of Worcester, Meilus was born in the early 1950s to parents who had recently arrived from Europe. His father had been deported from Lithuania to a work camp in Norway. From there he escaped to Sweden, where he got married. Meilus graduated from a Catholic high school in Worcester and then enrolled at WPI, ultimately earning a bachelor's degree in chemistry and an M.B.A. While he was an undergraduate he heard that WICN needed a host for a Lithuanian program.

When he's not on the air, Meilus is a systems effectiveness manager with M/A-COM in Waltham, Mass. Formerly he was a quality control engineering supervisor at Raytheon in Northboro, Mass., and a product assurance manager at Englehard Precision Microwave Circuits in Milford, Mass. He lives in Auburn, Mass., with his wife, Terese, and their two children. He and Terese edit *Bridges*, a Lithuanian-American journal sent to 5,000 readers in the U.S., Canada and Australia.

Though American born, Meilus says he considers himself Lithuanian. Like most Lithuanian-Americans, he has strong feelings about the land of his ancestry. Those feelings might be summed up best in a song Meilus sent out over the airwaves one recent winter night. "Everywhere in the world is wonderful," the lyrics go, "but it's best in Lithuania."

—Ruth Trask

Ed Meilus reaches out to Worcester's Lithuanian-American community once a week from this radio studio.

EXCELLENCE IS...

Enhanced Facilities for Mechanical Engineering

WPI and mechanical engineering have grown up together. The college was founded in 1865, just as the machine revolution was beginning to transform the world. WPI, one of the nation's first colleges of engineering and science, was also one of the first to offer a program in mechanical engineering.

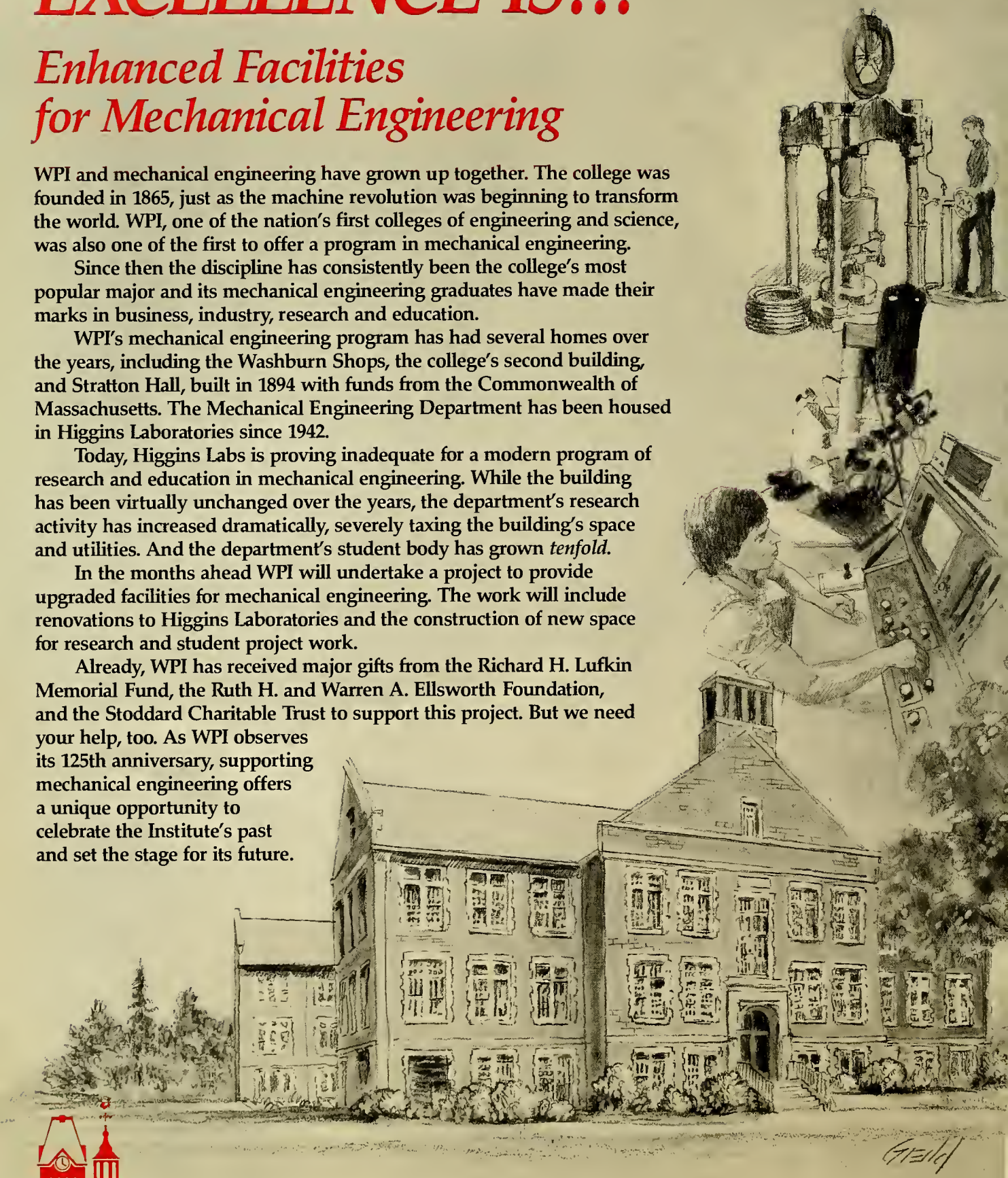
Since then the discipline has consistently been the college's most popular major and its mechanical engineering graduates have made their marks in business, industry, research and education.

WPI's mechanical engineering program has had several homes over the years, including the Washburn Shops, the college's second building, and Stratton Hall, built in 1894 with funds from the Commonwealth of Massachusetts. The Mechanical Engineering Department has been housed in Higgins Laboratories since 1942.

Today, Higgins Labs is proving inadequate for a modern program of research and education in mechanical engineering. While the building has been virtually unchanged over the years, the department's research activity has increased dramatically, severely taxing the building's space and utilities. And the department's student body has grown *tenfold.*

In the months ahead WPI will undertake a project to provide upgraded facilities for mechanical engineering. The work will include renovations to Higgins Laboratories and the construction of new space for research and student project work.

Already, WPI has received major gifts from the Richard H. Lufkin Memorial Fund, the Ruth H. and Warren A. Ellsworth Foundation, and the Stoddard Charitable Trust to support this project. But we need your help, too. As WPI observes its 125th anniversary, supporting mechanical engineering offers a unique opportunity to celebrate the Institute's past and set the stage for its future.



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WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

SUMMER 1990

Athletics at WPI

WPI Journal

VOLUME XCIII NO. 3 SUMMER 1990

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Front Cover: Representing WPI's athletic programs are (top half of photo, clockwise from far left) Greg Humora '92 (soccer), Pierre Schrappe '92 (tennis), Jeff Rozak '90 (ski team), Matt Oney '89 (wrestling), David Berthiaume '91 (cross country), Mike Ferreira '91 (crew), John Sturrock '92 (rugby), Randy Plasse '91 (football), Jennifer Tobin '90 (swimming), Conan Fitzgerald '91 (ultimate Frisbee), Kim Cloutier '90 (field hockey), Richard Bourgeois '90 (baseball), Elaine Lachance '91 (softball) and George Samiotes '90 (lacrosse); (bottom half, clockwise from far left): Brian Hanlon '90 (track and field), Danielle Bellavance '90 (lacrosse), Nicholas Carparelli '90 (basketball), Pamela Murphy '90 (volleyball), Robin Fontaine '90 (cross country), Jody Normandin '90 (basketball), Rebecca Reilly '92 (cheerleading), Pam Mamacos '92 (crew). Photo by Janet Woodcock. **Opposite:** One of the "athletic" gargoyles that peer down on visitors to Alumni Gym. Photo by Robert S. Arnold. **Back Cover:** A twilight run on WPI's all-weather track. Photo by Michael Carroll.

Staff of the WPI Journal: Editor, Michael W. Dorsey • Alumni News Editor, Ruth S. Trask • Writers, Bonnie Gelbwasser and Neil Norum • Designer, Carol Hoyle Ballard • Photographer, Janet Woodcock • **Alumni Publications Committee:** Samuel Mencow '37, chairman • Paul J. Cleary '71 • James S. Demetry '58 • Judith Donahue SIM '82 • William J. Firla Jr. '60 • Carl A. Keyser '39 • Robert C. Labonté '54• Roger N. Perry Jr. '45• The *WPI Journal* (ISSN 0148-6128) is published quarterly for the WPI Alumni Association by the Office of University Relations. Second class postage paid at Worcester, MA, and additional mailing offices. Printed by The Lane Press, Burlington, Vt.

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Putting On Our Top Hat, Tying Up Our White Tie

Like the two-faced Roman god Janus, who could look backward and forward at the same time, WPI in 1990 has divided its attention between the glory of its 125-year history and the promise of its future. With this issue, the *WPI Journal* also marks an important transition between two eras.

Eight years ago, WPI became a charter member of a new experiment in college magazine publishing known as the Alumni Magazine Consortium. The AMC, based at Johns Hopkins University, began as a confederation of five college and university magazines and grew in time to include seven publications.

The consortium was established, in part, to provide design and production services to its members. Its staff of editors and designers would take articles, photographs and artwork supplied by member institutions and turn them into finished magazines. As a member of the AMC, a college could produce a first-rate magazine without having to employ a magazine production staff.

The consortium provided another important service. Each issue of every quarterly magazine published by the AMC included a 16-page center section called the "core." Included in the core were articles on a wide range of subjects of interest to readers of the AMC magazines. The writers of these articles used as resources the faculties, staffs and alumni of member institutions. Four times a year, inclusion in the core placed WPI before an audience that at times numbered as many as 250,000 readers in the Northeast and mid-Atlantic states.

The AMC's membership has gone through a few ups and downs over the past eight years. Most recently, in 1989, the loss of two members reduced the consortium group to just three magazines—the *WPI Journal, Villanova Magazine* and *Johns Hopkins Magazine*. With such a small group it was no longer economically feasible to publish the core and this section was discontinued upon publication of the Winter 1990 *Journal*.

Without the core, WPI could no longer justify its membership in the consortium, and our last AMC issue was published this past spring. Leaving the consortium gave us an opportunity to step back and look at how we design and produce this magazine. We saw some ways we could make this a more attractive, lively and readable publication, and we've implemented many of them in the issue you hold in your hands. These include new approaches to design, improved text and cover stocks, and enhanced use of photographs.

We also saw a way to cut our printing costs considerably and, at the same time, improve the appearance of this 93-year-old publication. Beginning with this issue, the printing of the *Journal* is being handled by The Lane Press in Burlington, Vt., a specialty publisher that prints nearly 100 magazines with the most up-to-date printing technology.

To inaugurate our new look we've chosen a special theme: athletics at WPI. A full 27 pages of this issue is devoted to telling the story of the role athletics play in the lives of our students and our alumni. We hope you enjoy it and we welcome your comments on the new *WPI Journal*.

Leading traditional tree ceremonies are Edward Stokel '46 (top photo) and Joseph Hearne '47 (bottom).

Corrections: Several readers have drawn our attention to an error in the Spring 1990 issue of the *Journal*. A photograph illustrating Lora Brueck's article on Commencement at WPI was incorrectly identified as the 1947 class tree ceremony, with Joseph Hearne presiding. The photograph was, in fact, of the Class of 1946 ceremony (taken in 1945) and the student in the foreground was Edward Stokel. We've reproduced the original photograph above, along with a photo of the 1947 ceremony.

Otto Wahlrab '54 reported an historical error that slipped into the most recent installment of "Timeline." In editing the story, I added what I thought would be an interesting tidbit—the case of Lizzie Borden. The problem was, I placed this famous murder case in 1927. That was the year Lizzie Borden died; the murders actually occurred in 1893. You'll get to read about this case again in this quarter's installment of "Timeline."

—Michael Dorsey

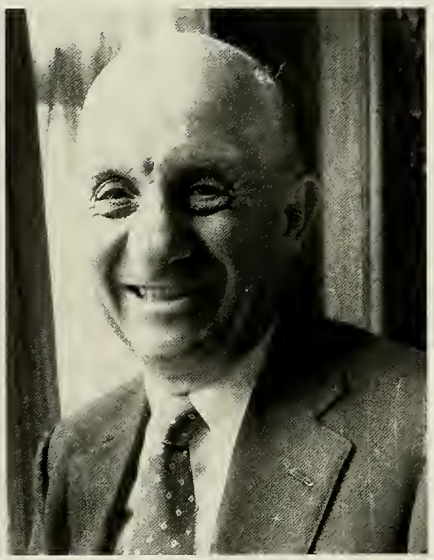
Helping Secure The Future of Athletics at WPI

WPI is blessed with an outstanding mix of sports activities and resources. The Institute's students can participate in organized sports as members of 18 intercollegiate and 22 club teams, and as participants in an extensive intramural program. All undergraduates take part in physical education classes that emphasize lifetime involvement in sports. And, students, faculty and staff are free to use WPI's facilities for recreation and keeping in shape. Few institutions of our size can match the breadth—and the success—of this impressive program.

Even fewer colleges can boast of athletic facilities the quality of WPI's. In the 1960s Harrington Auditorium was completed, providing a first-rate environment for many of the college's indoor sports programs. In the mid-1980s, WPI alumni and friends invested $1.8 million to upgrade most of its outdoor athletic facilities. The latter project included the construction of six new tennis courts, new softball and baseball diamonds, and a new all-weather track and multipurpose synthetic-turf field.

It's hard for some of us to believe, but we carry out this program (well-described in this issue of the *WPI Journal*) for a student body of 2,600 undergraduates and about 400 full-time graduate students. We also manage to contain it all within a campus that has grown little since I arrived as a freshman some 37 years ago. Fortunately, all-weather facilities and field lighting have enabled us to make fuller use of the space we have.

Not surprisingly, offering such an extensive program is expensive. Offering organized sports teams runs into a bit of money—no matter how modest the cost may be for some sports. For example, our track program costs about $10,000 per year, men's and women's swimming together cost about $10,000, baseball costs about $8,600, and field hockey costs about $9,000. Add the cost of salaries, facility maintenance, equipment and the other costs associated with a college athletic program and you begin to see just how much it costs WPI to maintain its commitment to athletics.



NEIL NORUM

George Abdow '53 has issued a challenge to WPI alumni.

As budgets grow increasingly tighter, it becomes more difficult to sustain the diversity of our sports program. Each year when the budget is drawn up, athletics must compete with other priorities for funds. For example, the increasing financial aid budget, which allows worthy and talented students access to a WPI education, is growing at a rapid clip and consuming a larger and larger share of the Institute's budget pie.

Still, if we are to continue to attract good students—and keep those who are already enrolled—we must provide high-quality support resources, including sports and recreation programs. So the balancing act continues—how much should the Institute allocate for "access," how much for sports, how much for books, how much for physical plant maintenance, and so on.

With that in mind, WPI is beginning—for the first time—an endowment program for the Department of Physical Education and Athletics. Future income from the endowment will be used to help sustain some of the outstanding programs described in the pages that follow.

Here's how it will work: For every $1 million of endowment, about $55,000 will be generated annually for use in any number of important ways. Other earned income will be retained to sustain the purchasing power of the college's endowment. Team uniforms, wrestling mats, ankle rehabilitation machines, turf management and restoration—much of these and other costs could be covered by an ongoing, long-term, successful endowment program. Restricting the endowment to physical education and athletics will help ensure that WPI can maintain these programs at the same quality that many of you enjoyed as athletes and participants during your years here.

Beginning with the 1990-91 WPI academic year you'll have an opportunity to make a gift directly to this endowment. For those who haven't participated in the *Campaign for Excellence*—or have done so modestly—we hope you will want to make an investment in this initiative, which helps produce a better WPI for all of us.

To help us launch this initiative and get it "off the mark," George T. Abdow '53, president of the WPI Alumni Association, has issued us all a challenge. For every $2 contributed to this new endowment fund for athletics, he'll ad $1. He has pledged up to $100,000 to this challenge. So think about what your renewed or enhanced support can accomplish as you read through this issue.

I'm proud of the diversity and success of our sports programs—aren't you? So, the next time you attend a home game at WPI or read about the success of our sports teams or, perhaps, think back on the positive experiences you had as a WPI athlete and the way those experiences enriched your life, why not make a gift to this important new fund. We'll all be the better for it.

—Donald F. Berth '57

Berth is vice president for university relations.

The Games Students Play

By Michael Dorsey

THROUGH ATHLETICS, WPI STUDENTS GAIN SKILLS AND INSIGHTS THAT ENHANCE THEIR COLLEGE EXPERIENCE, AND MEMORIES THAT WILL LAST A LIFETIME.

Tech wants athletes."

That's how Herbert F. Taylor '12, then secretary of the WPI Alumni Association, started a 1934 editorial in the *WPI Journal* that called on the Institute to offer athletic scholarships. Tired of seeing the WPI football team go down to defeat year after year, Taylor proposed actively recruiting good athletes who also happened to be good students and paying them to come to WPI and play.

The proposal brought WPI a flurry of national publicity that, in turn, generated more than 150 applications from prospective students around the country. In the end, 27 athletic scholarship winners enrolled with the Class of 1939. Their talents no doubt contributed to the exploits of the undefeated football and soccer teams of 1938 and the winning basketball teams of the late 1930s.

Despite its seeming success, the program was not continued. Perhaps the college took to heart the words of a writer at *The Hartford Courant*, who cautioned, "It will cost Worcester Tech and its alumni a lot of money to buy enough material for a team that will win consistently, but the price in loss of academic respect will be harder to pay."

In the years since that brush with "big-time" athletics, WPI has, from time to time, questioned the purpose and value of its athletic programs. It has wondered, among other things, whether it can field competitive intercollegiate teams and still maintain its "academic respect." It has asked itself what students really get out of their participation in sports and what value it adds to their educational experience. And, perhaps most important, it has asked whether the merits of the college's athletic programs justify the significant cost of maintaining them.

Time and again, the Institute has found the answers to those questions in the experiences of its students, who say they gain through participation in athletics, not just a welcome counterpoint to the rigors of WPI's academic program, but lessons and memories that greatly enhance their college years.

"Athletics makes for well-rounded students," says Raymond R. Gilbert, director of physical education and athletics at WPI. "Through sports they learn social skills, they develop a loyalty to their school, and they forge close friendships. All in all, athletics is a good training ground on which students learn values that will carry over into later life."

"We see tremendous growth in students who play a sport for four years," adds Bernard H. Brown, vice president for student affairs. "They learn lessons of life. They discover that the skills that aid them on the field aren't really all that different from the skills they'll need when they enter the job market—interpersonal ability and leadership development."

As Becky Griffith '91, captain of the women's swimming team and daughter of head swimming and baseball coach Whit Griffith, puts it, "WPI's athletic programs have the same goal as its academic programs. They encourage students to get the most out of their college experience."

The skills and values WPI seeks to impart through its athletic programs are, to some degree, a reflection of its membership in Division III of the National Collegiate Athletic Association. The NCAA sanctions three primary levels of college athletics. While the association lists many attributes that distinguish the three levels, the most important is financial aid. While Division I and II colleges and universities can offer scholarships to athletes—in essence, paying students to play—Division III schools must treat their athletes no differently from the way they

(Opposite page) Running back Joe Uglevich '90 struggles through the line, aided by a block from center Mark Schweitzer '90.

PHOTOS BY JANET WOODCOCK

Showing the strains of physical exertion, crew team members MaryBeth Liener '90, Stella Shaw '91, Michelle Marcoux '91, and Carmen Barillas '91 complete a practice run on Lake Quinsigamond.

treat other students.

At Division III schools, academics must come first. Participation in sports must be an adjunct to the experiences of the classroom and the laboratory, and must emphasize the benefits students realize as athletes, rather than the benefits others, as spectators, may realize from watching their performances on the field or the court.

The Division III philosophy is, in many ways, the essence of the message of Grantland Rice's classic verse: "When the One Great Scorer comes to write against your name, he marks—not that you won or lost, but how you played the game."

Athletics didn't always enjoy such a special place in the life of WPI students. During WPI's formative years the Institute offered its students virtually nothing in the way of organized sports. It was the students themselves who founded WPI's first teams in the 1870s and who inaugurated an annual field day, which included many track and field events, in 1880. The students were also responsible for the college's early athletic facilities. They built the Institute's first "gymnasium," actually a collection of homemade exercise apparatus set up in a grove near the Washburn Shops, and they constructed a crude track near Boynton Street for the field day events.

By the end of the century, the college had joined the New England Intercollegiate Athletic Association and enrolled its first true sports star—Harry Dadmun '91, who established a slew of records in running events—many of which stood for years—and won the national championship in the half-mile event in 1890.

When Thomas Mendenhall, WPI's third president, arrived in 1894, WPI athletics received a much needed shot in the arm. Mendenhall formed the Athletic Association and authorized the construction of a new cinder track. It would be 15 years before WPI built another athletic field. Funded by the college and its graduates, Alumni Field was ready for its first football game—a match-up between WPI and RPI—in 1914. Alumni also assumed the bulk of the cost of building the college's first true gymnasium, which was completed in 1916. The Fuller Swimming Pool, a gift of Henry J. Fuller, Class of 1895, and John Aldred, was added to Alumni Gym in 1926.

To oversee its expanding athletic programs, WPI hired its first full-time athletic director, Percy Carpenter, in 1916. Carpenter served until 1952. In the decade or so that followed his retirement, the college undertook a significant expansion of its indoor athletic facilities. In 1961 an addition was built onto Alumni Gym, providing, among other things, a training room, varsity lockers and bowling lanes. Harrington Auditorium, completed in 1968, is considered one of the finest gymnasiums among small colleges in New England.

The college completed the crown jewel of its improved athletic facilities in the mid-1980s when, with substantial support from its alumni, it replaced the frequently flooded cinder track and the fragile grass of Alumni Field with new all-weather surfaces. The renovations included the realignment of the softball and baseball fields and the installation of six brand new tennis courts.

The Secrets of Their Success

If a lack of turnover is any measure of job satisfaction, then being a varsity coach at WPI must be one of the most rewarding jobs in the world. The 10 members of the Institute's coaching staff have collectively put in more than 150 years of service.

Among their ranks are the likes of Merl Norcross, who last year completed 38 years as head track coach; Alan King, who has coached 33 seasons of soccer and tennis; Mel Massucco, whose 23 years of service have included stints as head football coach and, more recently, golf coach; Phil Grebinar, head wrestling coach for 18 years; and Ken Kaufman, ready to start his 15th season as coach of the men's basketball team.

No matter how long they have been on the job, all of WPI's coaches say they face common challenges. First and foremost is the task of finding enough students with the right combination of academic achievement, career interest, and athletic ability to fill out 18 varsity teams.

(Clockwise from above) Merl Norcross, Phil Grebinar and Alan King.

"Every coach in Division III has to beat the bushes to be good," says Naomi Graves, who has coached the women's basketball and tennis teams since 1985. "It's a labor of love, but fielding a team is tough."

"It takes a lot of kids to be any good at this sport," notes Jack Siedlecki, head football coach. "Recruiting can be difficult and we don't always get the best kids. Kids want to play at the highest level they can. If they get recruited by a Division I school, they'll often give up an engineering education to go there."

To be a successful recruiter, a coach must find athletes who are looking for the type of academic program WPI offers. To do this, the coaches work closely with WPI's Admissions Office, often sending information about the college's athletic programs to every applicant who indicates an interest in sports. Their efforts augment the work of the admissions staff, notes Robert G. Voss, executive director of admissions and financial aid. "The coaches are a big asset to us," he says. "They identify students all over who may not have considered WPI without the coaches' encouragement."

The numbers game is an especially difficult one for the coaches of WPI's women's teams, who start with a pool of fewer than 500 undergraduates. "The first challenge I face every year is just getting a team together," notes volleyball coach Nancy Vaskas. "Everybody loves to play volleyball, but it's tough to find kids who can really play well. I'm willing to try anyone who's interested. Sometimes they come out with no experience and become very, very good."

Once a team is assembled, how does a coach keep students coming to practice and giving their all? The secret, many say, is balancing the physical and mental demands of preparing for competition with opportunities for students to have fun.

"You can't make it drudgery. You can't be a drill sergeant," notes Kaufman. "We get after the team when they're not performing up to their ability, but we also try to make that hour and a half a day of basketball something they look forward to."

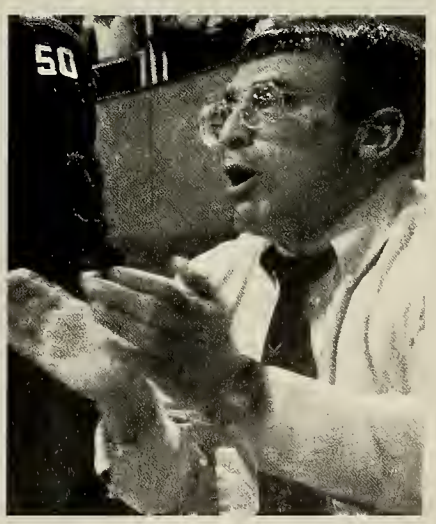
It's also important to make students feel appreciated, says Merl Norcross. "I have something to say to every kid, every day. That makes them feel that it's important that they're there."

Letting students participate as much as their talents and interest dictate is also part of the role of a good coach, notes Siedlecki. "No matter how loyal you are to the program or how enjoyable it might be, if you don't get to play, it won't be much fun after awhile."

Students and coaches find that WPI's philosophy about athletics also helps keep the experience of coaching and playing enjoyable. "Winning isn't everything at WPI," notes Norcross. "I've been successful, but the college would still support me if I didn't have a winning record."

What does all this add up to? Most of WPI's coaches say the most rewarding outcome of their efforts is the satisfaction of keeping in touch with students after they graduate. "Our alumni support us. They support our kids," says Phil Grebinar. "They come to meets, they come back for Homecoming. That's what I enjoy the most."

—Michael Dorsey



Tammy O'Dea '92 commands the court.

As the scale and quality of WPI's athletic facilities have expanded, so too has the variety of the Institute's athletic programs. Today students have the opportunity to take part in 18 varsity sports and 24 club sports (see table). The intramural program offers teams of students and faculty and staff members the opportunity to go head-to-head against each other in more than 15 sports. All told, these programs annually attract about two-thirds of the college's undergraduates.

"With this combination of activities, we are just about where we should be," notes Ray Gilbert. "We really couldn't offer any more with a student body our size."

Varsity sports constitute the most visible components of WPI's athletics program. The 18 varsity teams play full schedules of games, matches or meets against teams from many of the best colleges in the Northeast. More than 580 students—over 21 percent of the undergraduate student body—take part in varsity sports each year.

"We have, for a college our size, a very large number of varsity programs," Brown says. "MIT, for example, which is a much larger institution, has a similarly sized program. Of course, this can create some difficulty during particular seasons when we find ourselves spread a little thin, especially in our women's programs."

While fielding a full range of varsity teams can be a challenge, the varsity program has managed to score some impressive accomplishments in recent years:

- The football team chalked up its third undefeated season in 1983.
- The field hockey team, which amassed a 36-3-1 record over the past two years, was the NEW-8 champion and played in the NCAA Division III Northeast finals in 1989.
- The wrestling team, which has not had a losing season in over 15 years, placed first in the New England College Conference tournaments of 1985 and 1987. The team finished second in 1989.
- The men's track team, which has completed 23 consecutive winning seasons, won the New England Championships in 1987 and went undefeated in 1962 and 1974.
- The men's basketball team posted a record of 20 wins and eight losses during the 1984-85 season, finishing the year as NCAA champions. The team traveled to California earlier this year to play its first-ever game with Caltech.
- The women's basketball team, which reached the finals of the NEW-8 Tournament in 1989, won the ECAC Division III Championship in 1987.
- The volleyball team won the Massachusetts State Division III Class C Championship in 1987.
- The soccer team, which has made seven appearances in NCAA Division III tournaments over the years, has also won six New England Intercollegiate Soccer League titles.

WPI's Sports Programs

Varsity Teams

Baseball	Softball
Basketball*	Swimming*
Cross Country*	Tennis*
Field Hockey	Track*
Football	Volleyball (women's)
Golf	Wrestling
Soccer (men's)	

Club Teams

Bowling*	Rugby*
Cheerleading	Sailing
Crew*	Ski Club
Cycling	Ski Team
Fencing*	Soccer (women's)
Freestyle Wrestling	Ultimate Frisbee
Ice Hockey	Volleyball (men's)
Karate	Scuba
Lacrosse*	Water Polo
Outing	

*Indicates men's and women's teams.

Athletic director Raymond R. Gilbert oversees a bustling sports program.

Less visible than their varsity cousins, WPI's 24 club teams provide students with an equally challenging, though often less competitive athletic experience. "It's less structured than the varsity program," notes Brown. "While we do have part-time coaches, this is something many other schools don't provide for their club program. The program is also a bit more flexible. We are not restricted by NCAA guidelines and students often assume much of the responsibility for the success of their sports."

"In varsity sports, we're looking for students who want to commit to a sport where they will be asked to practice every day, to compete at the varsity level, to travel, and to meet other college athletes and compete against them," notes Naomi Graves, assistant to the athletic director for women's sports and head coach of the women's basketball and tennis teams. "In club sports the commitment is less."

Like the varsity program, WPI's club program has had its share of successes. This past winter, for example, the 18-0 ice hockey team competed in the finals of the National Club Hockey Tournament.

For students who wish to play team sports, but do not have the skills, the time or the desire to join an intercollegiate team, WPI runs an extensive intramural program. Each year hundreds of teams, often sponsored by fraternities, student clubs or academic departments, compete for trophies and, more important, for the sheer fun of it. Practicing and competing when the facilities are not needed by the varsity and club

teams, intramural teams constitute the most popular element of the college's extracurricular athletics program, with more than half of all students taking part. Like the varsity and club programs, intramurals add an important dimension to WPI life.

"Our son always loved sports of every kind, yet was never college varsity material," noted Julie I. Brown, mother of Linwood L. Brown III '90, in a recent letter to WPI President Jon C. Strauss. "He thought his playing days were over when he reached college. Quite the contrary. Through intramurals, he played sports that he had never been able to play before. He loved every moment of it and was also able to work off energy, frustrations and tensions."

Though organizing athletic teams is a large part of the job of WPI's Department of Physical Education and Athletics, physical education, as the name of the department implies, is also an important element of its mission. Under the WPI Plan, WPI's innovative undergraduate educational program, all students must complete a physical education requirement. The requirement— equivalent to one regular course—is usually completed over the course of four of WPI's seven-week terms. Students can also fulfill the requirement by playing on a varsity or club team.

"We try to develop the kinds of courses that not only teach students skills, but also deal with issues of physical conditioning, nutrition and health awareness," notes Brown. "The emphasis is on developing an appreciation for exercise and health that will prepare them for their lives and careers after they leave WPI."

Gregory Tucker '92 dribbles by a Trinity kicker.

First baseman Tim St. Germain '91 waits for the right pitch.

"I get as much enjoyment out of teaching physical education as I do from coaching," notes Alan King, head soccer and men's tennis coach, who also teaches tennis, racquetball and squash. "It's gratifying to start off with students who have little or no skill and see them leave your course with the ability to do something physically that they couldn't do before. Then, when you see them come voluntarily, outside of class, to practice and play, you know this is something they will carry into their future lives."

When WPI's facilities are not hosting varsity, club or intramural competitions, or serving as classrooms for physical education courses, they are made available to students and faculty and staff members for recreation. Maintaining such a variety of athletic programs requires considerable financial and human resources. In addition to 10 full-time coaches and instructors, the Department of Physical Education and Athletics employs six support staff members, including trainers and an equipment manager. More than 17 part-time employees work as assistant varsity coaches and as coaches for junior varsity and club teams.

When salaries are combined with the cost of equipment, supplies, insurance, transportation for traveling teams, and fees for officials, the cost of maintaining the athletic programs runs close to $1 million, notes Brown. This figure, he adds, does not include the cost of maintaining the buildings, swimming pool, tennis courts, athletic fields and gymnasiums. One constantly ris-

(Continued on page 11)

WPI's Athletic Facilities Rock Around the Clock

(Clockwise from above) Students work out in the weight room in the basement of Alumni Gym. Built in 1968, Harrington Auditorium comes alive on winter nights. Mel Massucco, shown here in the Institute's bowling lanes, directs a hectic intramurals schedule.

Fats Waller didn't have WPI in mind when he wrote, "this joint is jumpin'," but the lyric aptly describes a typical day in the life of WPI's athletic facilities.

From the crack of dawn until midnight—on weekdays and many weekends—in every season—Harrington Auditorium, Alumni Gymnasium, Fuller Pool, the tennis, squash and racquetball courts, the bowling lanes, the weight room, the all-weather track and the playing fields are not only jumping, but bouncing, bounding, sprinting and swimming with athletes.

During the academic year these facilities are used by 18 varsity, 24 club and dozens of intramural teams. More than 3,000 students and faculty and staff members use them in pursuit of recreation and exercise. The fields and gyms put in overtime as WPI hosts major college championships—among them the New England Women's Eight (NEW-8) Conference, Eastern Collegiate Athletic Conference and National Collegiate Athletic Conference tournaments, and the New England Division III championships.

The fields and gyms are also venues for community baseball league games and community fund-raising events, like the annual "Hoops for the Homeless" basketball game. And, during the course of an average year, between 20,000 and 30,000 people attend high school championship games in football, field hockey, soccer and basketball held at WPI.

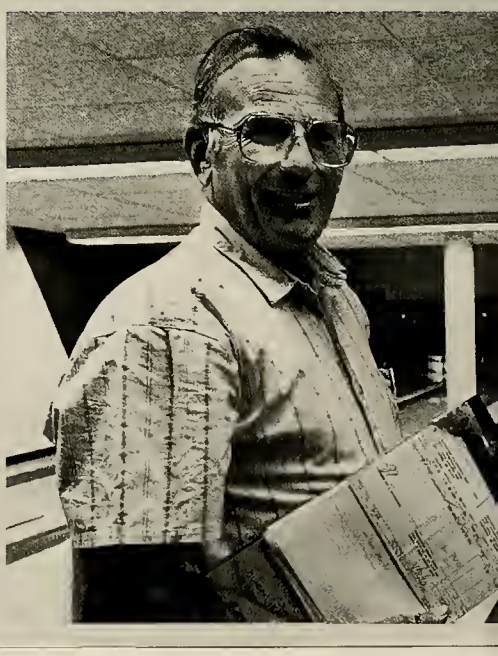
When the school year ends the athletic facilities get little chance for rest. During much of the summer the college offers sports camps for young athletes. In addition to generating revenue for the college, the camps annually expose thousands of young athletes (and potential WPI students) to the college and its athletic facilities. The facilities are also made available to visitors who stay on campus while attending conferences in the area and to the more than 100 high school students who attend WPI's Frontiers in Science and Mathematics program.

Some of the facilities do double duty. Harrington Auditorium, for example, is often transformed into a dining hall for major campus events and hosts everything from student registration to concerts by the likes of Dizzie Gillespie and 10,000 Maniacs.

With all this activity, it's not surprising that drawing up schedules for the facilities can require the dexterity of an orchestra conductor. As director of physical education and athletics, Raymond Gilbert has the overall responsibility for this difficult job, but delegates the day-to-day scheduling to Naomi Graves, assistant to the athletic director for women's athletics, and, during the summer months, to Mel Massucco, director of intramurals.

The practice schedule must take into consideration all of the scheduled home athletic contests (last year there were 36 in the fall, 46 in the winter and 35 in the spring). In addition, it must accommodate a lengthy list of eligible users. "ROTC has used the gyms and the track for two hours many mornings. A student-run aerobics class in Harrington attracts some 60 to 80 people three days a week at noontime during the school year. The Central Mass. Striders use the track one night each week, and students from nearby Tatnuck Elementary School swim or play basketball for an hour each week. The Footpounders, a group of faculty and staff runners, train at noontime on the outdoor track or in one of the gyms," says Graves.

"On top of all this, we try to leave the



gyms open as much as possible for informal play. The other facilities, including the pool and the weight room, are open as much as possible for recreation."

On a typical winter evening, Graves notes, Harrington Auditorium bursts at the seams. "Starting at 4:30 p.m., while the women's basketball team works out on the main floor, the cheerleaders might be practicing in the balcony, the fencing team drilling behind one set of bleachers, intramural table tennis teams competing behind the other set, the ski club exercising on the stairs, and indoor track runners doing starts and stops in the main lobby.

"Two hours later, as the men's basketball team starts its practice," she says, "the karate club might be using the balcony while the men's lacrosse and cycling teams train for the spring season on the stairs. Later in the evening, intramural soccer and volleyball games begin on the floor while the crew teams take over the stairs. It's wild!"

During the fall and spring, the schedule for Alumni Field can be equally busy. A fall evening might see the football, soccer and field hockey teams getting in practice time, followed by a round of intramural flag football, soccer or softball games.

As the number of students interested in intramural sports has increased over the years, Massucco says managing the schedules has become more and more of a challenge. "Ten years ago," he explains, "there were only 13 intramural teams. Now more than half the students and many faculty and staff members participate."

Last year, Massucco says, some 48 intramural teams played basketball, more than 130 people bowled, 41 teams competed in floor hockey, 29 teams played soccer, and 28 teams played softball.

The success of the intramural program has led to some marathon sports events. "One Saturday, when the varsity track and softball teams were away, we played from 10 a.m. until dark," Massucco recalls. "We played an intramural softball game every hour and a quarter on three fields."

Still, Massucco says, while giving all athletes a fair shake can be a perilous pursuit, the keen demand for the athletic facilities is an excellent indication of how successful the college's athletic programs have become.

—Bonnie Gelbwasser

(Continued from page 9)

ing cost is that of providing up-to-date and safe equipment for the college's athletes. "If we're going to put athletes on the field," Brown says, "we have to make sure they're well protected with the safest equipment."

One person who knows well the cost of safely outfitting WPI athletes is Jan Bialonozka, who has been the college's equipment manager for more than 25 years. "Here's one example," he says, piling up the pads, jersey, pants, shoes and helmet that a typical football player wears. "We recently bought new shoulder pads. These are the best, the safest. Each pad runs about $175. The jerseys cost about $47, the pants cost $52, the shoes cost $55, and the helmets run $106. So, to outfit a player for games we are talking about $435."

Like all divisions and departments at WPI, athletics and physical education must compete for its slice of WPI's budget pie. With expenses for priorities like student financial aid, faculty compensation and the maintenance of modern science and engineering laboratories rising rapidly, it is inevitable that many items on the department's "wish list" will go unfunded, notes Ray Gilbert. While individual gifts from alumni and help from the Poly Club (an alumni group dedicated to support of WPI athletics) meet some needs, others remain.

"While our facilities and equipment are excellent, there are certainly things that we'd like to improve or add," he says. The training room in Alumni Gym, Gilbert notes, is out-of-date and the weight room, while recently renovated, needs additional equipment to become the fitness and wellness center the department would like to make available to students.

"We certainly need to upgrade the locker and laundry facilities in Alumni Gym; Alumni Field could use additional seating on the home side; improvements to the press box and concession areas, and new wiring for the communications system used by coaches during athletic contests are needed; the baseball and softball fields could use dugouts, and we need another practice field."

Gilbert says the department would also like to add additional computer facilities for coaches and a video classroom. "Most college football teams are converting from film to video to record their games. We don't have the equipment to view tapes we receive from other teams. We'd like to set up a video classroom that we could use for viewing these tapes and for a variety of other educational purposes."

One of the most expensive items on the "wish list" is an expansion of the college's pool. Built in the 1920s, it is "probably the

(Above) Michael Solomita, who recently received a master's degree in biomedical engineering, clears the puck. (Opposite page) Relay team member Scott Kelly '93 prepares to hand off to teammate Brian Daly '91.

only four-lane, 20-yard pool still used in competition in New England. It's probably one of the few pools of its type in competitive use anywhere," says Whit Griffith, head coach of the men's and women's swimming teams, who notes that the small size of the pool limits the number of students who can participate in practices and has placed an upper limit on the size of the college's two swim teams.

Upgrading the pool and adding facilities for diving (the swim teams' divers now practice in the pool at Holy Cross College) is, Gilbert admits, a wish he hopes will come to fruition some time in the near future. In the meantime, notes coach Griffith, the performance of WPI's swimmers—eight of whom have earned All-America honors—is a tribute to how much WPI students can do with the resources they have available.

While WPI goes to great pains to offer the best in athletic programs and maintain the highest-quality facilities, few students actually choose to attend WPI primarily for the opportunity to participate in sports. Most say they were attracted to WPI, first and foremost, by the quality of the college's academic program.

Brian E. Hanlon '90 of Salem, N.H., says his performance on his high school track team generated some interest among a few Division I colleges and a few offers from Division II schools. In the end, though, it was the WPI Plan that figured most prominently his decision to apply to the Institute. "Ultimately, you choose a school because you know you'll get a good education there," he says. "After all, while you can continue to run track after you graduate, it's not going to make any money for you."

While Kristine Gatley '90 of Hull, Mass., had also participated in track and field in high school, she says she wasn't thinking about sports when she applied to WPI. "I came here because I wanted an engineering education," she notes. "I wanted to be close to home, and I wanted a small college. Sports was not an issue at all in my decision to come here."

Still, once she had enrolled, she joined the track, basketball and crew teams. She says it was a decision she will never regret. "I made friends that will stay dear to me for life. I think if I hadn't joined any sport my social life would have been miserable—that's if I had even survived WPI academically. Instead, this has been the best time of my life."

Deborah M. Sanna '93, a swimmer and soccer player at her high school in Madison, Wisc., came upon WPI more or less by accident while visiting colleges in Massachusetts and decided to apply here. "I realized after I found a school I liked for its academics, that since there were only about 2,500 students I could really get involved in a lot of things."

In short order, she says, she joined the women's soccer and swimming teams and the lacrosse club. "Being so far away from Wisconsin, I was extremely homesick," she says. "I decided I would definitely get to know people, and the best way to do that was to get involved with sports."

Balancing the commitment of time and mental energy needed to perform well in WPI's demanding academic environment with the time and physical energy needed to succeed in sports can be challenging, but many students who undertake the challenge say there are important benefits to be realized.

"I actually perform better academically when I'm involved in a sport," notes Kris Gatley. "When I'm playing sports I know I have to get to dinner on time; I have to get up early to get everything done. I make a list of things I have to do every night before I go to bed."

Gatley's experience is not unique, say WPI's coaches. "I think most students feel they do better academically while they're on a team," notes Judy Soderlund, head coach of the field hockey and softball teams. "Many say they need something to keep them on schedule, to enforce their time management. That's why some students play sports."

Soderlund and other coaches point to the number of Academic All-America awards, which recognize both athletic and academic achievements, that WPI students have garnered over the years—20 in the past three years alone—as evidence of the

WPI
WPI
WPI

positive influence sports can have on students.

The same determination and drive that make WPI's undergraduates good students help them excel as athletes, many coaches say. "Our kids face a tough academic load—they have homework all the time," notes Phil Grebinar, head wresting coach. "I think this makes them crave pressure, crave discipline. They like someone making it tough on them. They don't want it easy; they want to work hard."

Better grades are not the only benefits students take away from sports. While every coach has his or her personal observations on how sports prepare students for life, all agree that playing on a team enriches the college experience.

"Students develop a special camaraderie by playing on a team," notes Merl Norcross, head coach of the men's track and field and cross country teams. "They remain interested and active in their alma mater after they graduate and they develop lifelong friendships."

"A large plus is the self-confidence they gain," says soccer coach Alan King. "They learn that they can perform and be part of a team, as they will have to do in later life. They learn how to perform up to the expectations of the group, and also to achieve as individuals."

The lessons of teamwork are the greatest benefits Jack Siedlecki says his players receive. "When you go into industry, you'll have to be part of a team. Very seldom is it going to be you alone. You're going to work with a lot of people—you're going to like some of them and not like others. But, as a group you're going to have to work for the common goals of the company."

"Without a doubt, the best teaching we can do for life," says basketball coach Ken Kaufman, "is having a team learn to handle both defeat and success—especially defeat. If you lose—and when you play 25 games a season, you're asking for that—you analyze what caused the defeat, you try to improve, then you move on to the next game."

Another important lesson many student-athletes learn at WPI, all of the coaches agree, is that with patience, determination and practice, you can often accomplish more that you thought you were capable of. "One of the most gratifying parts of coaching," notes King, "is to see players who stuck with it and didn't give up when logic dictated that they should have quit. These are the kids who don't believe others' assessments of themselves, who think they can stay with it, who have the inner strength that makes it possible to keep going. They often manage to make it in the end."

Building a Women's Athletics Program From the Ground Up

When Patricia Graham Flaherty '75 enrolled at WPI in 1971, the college had been admitting women as undergraduates for just four years and had yet to start a formal athletics program for its female students. While Flaherty says it was the academic program, and not extracurricular activities, that attracted her to WPI, she says she still found herself longing for the opportunity to participate in sports.

"I wasn't a superstar athlete in high school," she says, "but I had played basketball, softball and field hockey. When I realized that there were no formal activities for women at WPI, I knew I wouldn't be totally happy until we had a women's athletics program."

Wasting no time, Flaherty contacted Bernard H. Brown, then dean of students and now vice president for student affairs. "He was supportive from the beginning," she says. "The women students were a small group with diverse interests and skill levels. We decided to start with a basketball team because it required the fewest number of players."

With Brown serving as fund-raiser, Flaherty filling the roles of recruiter, scheduler and coach, and male athletes donating their time as referees, the team was soon ready to face its first competitors. "I probably called every school in Worcester," Flaherty says. "If they had a team, I'd ask if they'd like to scrimmage us. If they didn't have a team, I'd ask if they'd like to start one." In its first year the women's program included club teams in basketball, softball and fencing. As early as 1972, the fencing team had enough members to send players to the Women's New England Intercollegiate Team Fencing Tournament.

While the women's athletics program was quick to get out of the blocks, it took a little longer for the WPI community to get used to the idea of having women athletes on campus. A 1973 article in *Newspeak* on the newly created women's crew team began this way: "Girls jogging? Girls lifting weights? You're right, it's the girls' crew team." By September the newspaper was talking about a 14-member team that "expects to maintain its record of being one of the top women's teams in New England."

Field hockey coach Judy Soderlund.

"It was a transition time for women's athletics, which were just reaching equality with men's sports everywhere," Flaherty says. The federal Title IX legislation, which mandated that colleges and universities that receive federal aid provide "equal opportunities for women," did much to bring women's programs into parity with men's sports offerings around the country.

(Left) Naomi Graves briefs the women's basketball team. (Right) On the volleyball court, team member Amy Shoemaker '92 goes for a kill.

At WPI, the "charisma and personality" of the women athletes also helped the program succeed, says Flaherty, who now has a sportsmanship award named in her honor. "If you go to a school that's primarily male, you have to be a little more outgoing. I suspect that many of the women were at the top of their classes and deeply involved in extracurricular activities in high school."

In 1975 WPI hired its first full-time woman instructor in the Department of Physical Education and Athletics. In her first year Sue Chapman organized a women's volleyball team, WPI's first women's varsity team. Varsity basketball, softball and tennis teams soon followed. Within a year the college joined the Massachusetts Association of Intercollegiate Athletics for Women (MAIAW), which enabled the teams to compete in championships. The college now also belongs to the New England Women's Eight (NEW-8) conference, which includes some of the region's most competitive women's teams.

"I always felt WPI was supportive of building the best women's program possible," Chapman said in an interview with the *WPI Wire* in 1988, when she left WPI to become athletic director at Worcester State College. "The Institute acknowledged that women's athletics were here to stay."

In 1985 WPI hired its second full-time woman coach, Naomi Graves, who is now assistant to the athletic director for women's athletics and head women's basketball and tennis coach. Judith Soderlund came on board as head field hockey and softball coach in 1988. Volleyball coach Nancy Vaskas joined the staff on a part-time basis in 1979.

Today, women athletes may choose from a varied menu of sports offerings. Each year about half of all women undergraduates make that choice. During the past academic year, 127 women undergraduates were members of a varsity team, 150 played club sports, and 103 participated on intramural teams.

Despite these positive numbers, it can still be a challenge to field a Division III women's team at WPI, notes assistant volleyball coach Karen Dzialo Frey, who received her bachelor's and master's degrees in electrical engineering at WPI and is currently studying for her Ph.D.

"We've gone from large teams to smaller teams. When I played as an undergraduate we had 13 or 14 players on our team; now we have eight," Frey says. Although many teams have been small, some have been successful, she says. "When that happens, the publicity helps the programs."

Having a strong women's sports program makes a difference to prospective students, Judy Soderlund adds. Students who come to WPI know that because the student body is small, they may have more opportunities to participate in athletics than elsewhere. "The coaches can spend more time with the students. We encourage them to do their best and we give them the red carpet treatment. If the academics at several schools are the same, women sometimes choose WPI because they know they'll be playing a sport, even if they're not a star athlete."

—Bonnie Gelbwasser

For these students, a Division III athletics program enables them to open doors that might not even have existed at a larger school. "If you look at the football team," says Siedlecki, "you'll see kids who could now play Division 1AA ball. They made themselves into that type of player. Through hard work, they became top-quality athletes. They may never have gotten the opportunity at another school."

Hard work and determination have carried a number of WPI athletes to national competitions. "Students at WPI can go as far as their talent and determination lets them go," says Norcross. "The college will be behind them. I've had students go to the nationals several times. That's something they will never forget."

In fact, when all is said and done it is largely memories that WPI student-athletes take with them after they have received their diplomas and set aside the mantle of competition—memories of the friendships forged, of the thrill of competing and winning, of the maturity and growth gained, and of the hard work and the rewards it brought.

"I look back on my athletic experience as a valuable part of my education," notes George T. Abdow '53, chairman of the board of the Abdow Big Boy Restaurant chain who played for WPI's football team in his undergraduate days. "It taught me the discipline of budgeting my time. It also taught me that if I really wanted to do something, I could find a way to do it."

"I've found that it has helped me set personal goals at work and to work to achieve them," says Bruce Carbone '85, whose discipline as a swimmer helped him break several school records and make it to the national championships twice. "This is easier to do in the swimming pool, where your performance is measured by the clock. You can immediately see that your work was worthwhile. I always set goals for myself at the beginning of the year— where I wanted to be in the New Englands and the Nationals. That experience helps me reach my goals now."

"People outside of sports can't realize what motivates a person to be an athlete," says Nicholas V. Carparelli Jr. '90, a four-year member of the basketball team who made the transition from student to alumnus this past May. "It takes a tremendous amount of dedication and discipline to be successful in a team sport. For the athlete, sports is more than an outside activity. It's really about the satisfaction you get from working hard and achieving something. That's what makes it so gratifying."

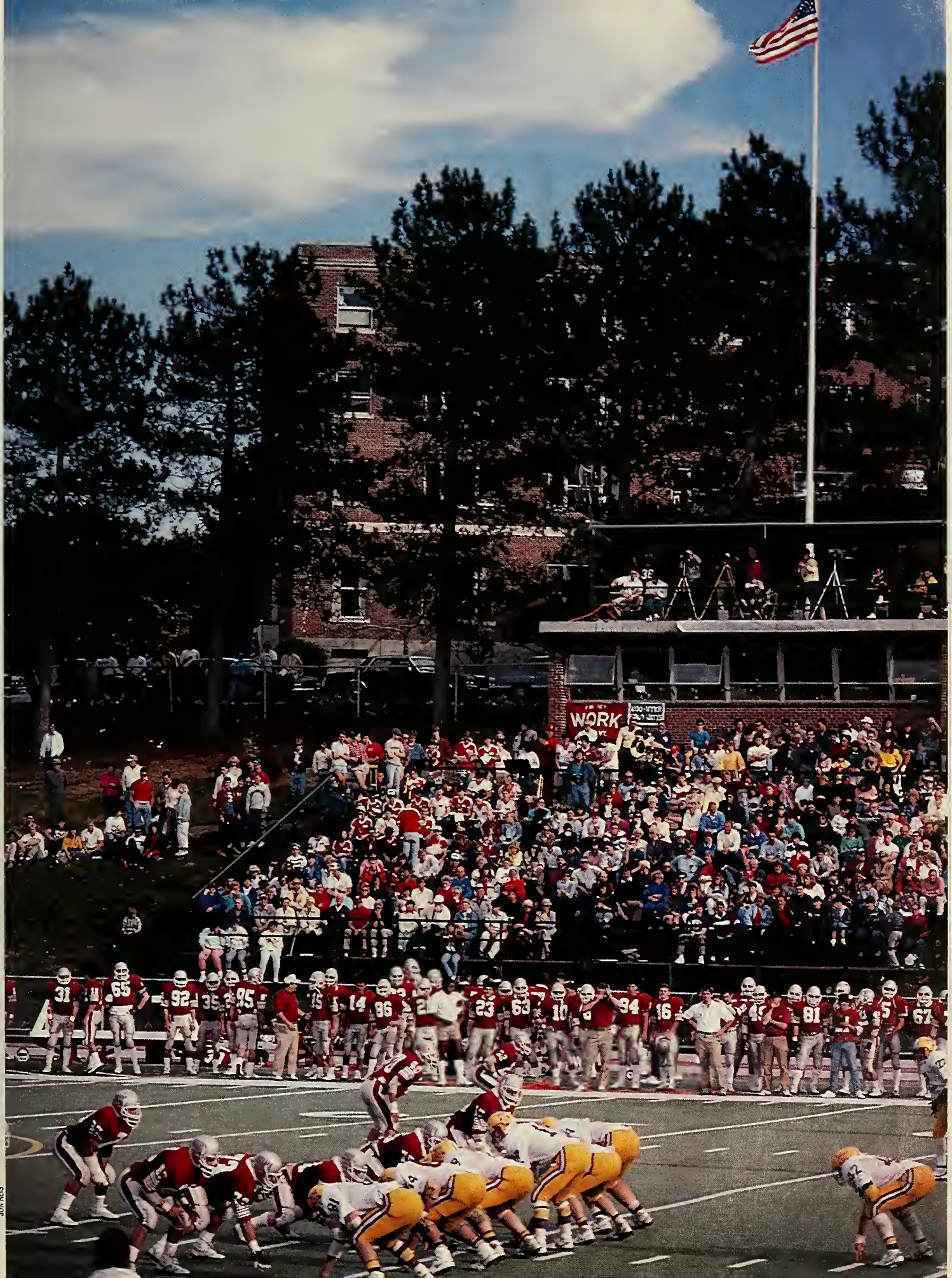
Reporting by Bonnie Gelbwasser and Ruth Trask contributed to this article.

On the Playing Fields of WPI

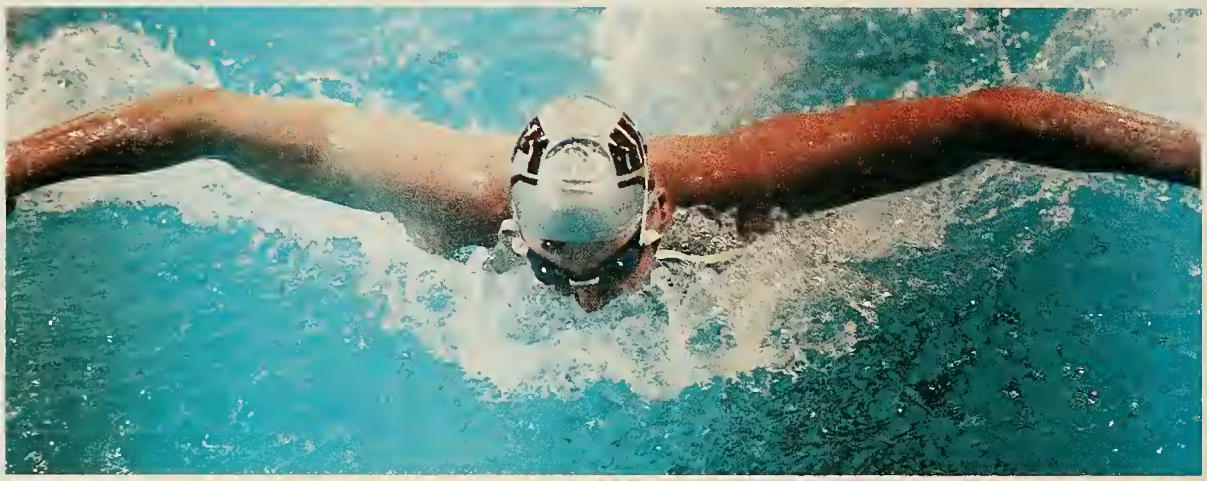
JANET WOODCOCK

"The Battle of Waterloo was won on the playing fields of Eton."

Arthur Wellesley, Duke of Wellington



JON REIS



JANET WOODCOCK

THROUGHOUT HISTORY, *writers and artists have observed in the spectacle of athletic competition a microcosm of our world. In the drama of sports—the exhilaration of competition, the highs and lows of victory and defeat, the joy of teamwork, and the satisfaction of personal accomplishment —they have found a model of the human experience.*

If sports truly embodies the essence of the human drama, then the venues where sports are played—the playing fields, the gym floors, the courts, the pools, the links and the lanes—are the stages where this constantly changing play transpires—complete with humor, suspense, heartache and triumph.

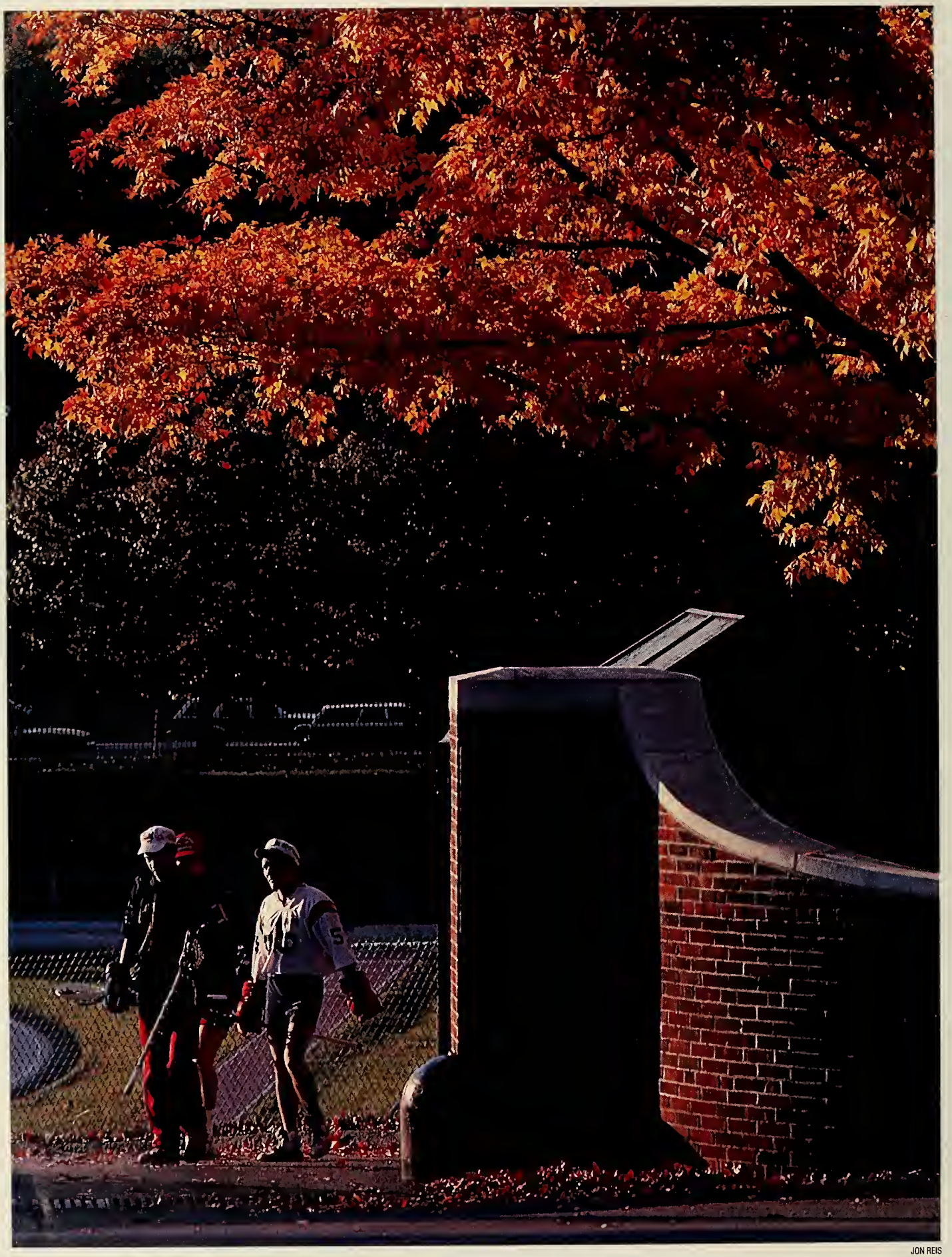
JANET WOODCOCK

In these pages we present just such a work—a drama in three acts: fall, winter and spring. It is a play performed by a cast of thousands of WPI student-athletes upon WPI's many athletic stages—Alumni Field, Harrington Auditorium and Alumni Gym, to name a few. Join us, then, as the curtain rises on athletics at WPI.

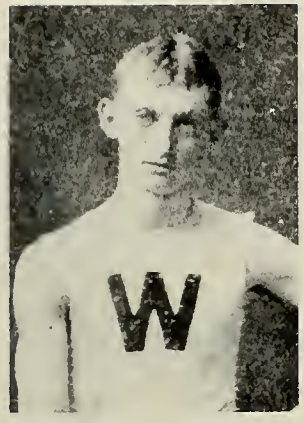
JON REIS

JANET WOODCOCK

(Page 16) Scott O'Connell '92 clears the last hurdle in a recent race at WPI. (Page 17) The Engineers line up against frequent rival Norwich University. (Opposite, top) Coming down the home stretch in Fuller Pool. (Opposite, bottom) Skip Bowker '90 goes for two points in Harrington Auditorium. (Above) Soccer practice on the Class of 1893 Field. The dome of the American Antiquarian Society building is in the background. (Left) Field hockey players Jody Normandin '90 (at left) and Kristin Baierlein '90 move the ball downfield. (Next page) Afternoon practice over, members of the men's lacrosse team pass through the gates of Alumni Field.



JON REIS



WPI's Athletic Medal of Honor Winners

By Michael Dorsey

Although WPI's Athletic Hall of Fame was first conceived by the college's coaches in the early 1970s, it was not formally launched until 1983. Since then 46 alumni, coaches, administrators and friends of WPI athletics have been added to its honor rolls and four new members will join in ceremonies in October. Honorees are chosen by the Athletic Hall of Fame Selection Committee on the basis of their athletic accomplishments, integrity, sportsmanship and character.

While the majority of members made their marks as student-athletes, several worked behind the scenes, including Ivan E. Bigler, coach of football, basketball and baseball from the 1920s to the 1940s; Ray F. Bourgault '42, longtime football game photographer; Percy R. Carpenter, WPI's first athletic director; Alan King, starting his 34th year as head soccer and men's tennis coach; Professor A.J. Knight '07, longtime supporter of WPI athletics, for whom a campus athletic field is named; Charles R. McNulty, for many years head baseball and basketball coach, assistant football coach, and now professor emeritus; Merl Norcross, head track and field coach for nearly 40 years; and Robert W. Pritchard, longtime athletic director and football coach.

Not surprisingly, several members of the Hall of Fame belonged to some of the college's most successful teams:

Fred Pickwick Jr. '22 and **Ralph W. White '23** played on the New England Championship basketball teams of 1920 and 1921.

Albert J. Raslavsky '39 and **Elmer T. Scott '41** were members of the undefeated 1938 football team. Scott played most of that season with his hand in a cast.

David McEwan '39 was a member of the undefeated soccer team of 1938 and won All-America honors as a soccer player.

Peter H. Horstmann '55 captained and **Henry W. Nowick '56** played on the undefeated 1954 football team.

Edward F. Cannon '68 and **Donald G. Lutz '67** were part of the undefeated 1965 soccer team. Cannon was a two-time All-American during his WPI years; Lutz also scored 1,212 points during four years on the basketball team.

WPI's first national champion, Harry L. Dadmun (above, left), was inducted in 1983. Suzanne Call Margerum receives her medallion from WPI President Jon Strauss in 1987 (above).

While it's impossible to acknowledge all the other members of the Hall of Fame in this space, here are a few who achieved some impressive "firsts" and "mosts" :

Harry L. Dadmun, Class of 1891, WPI's first national champion, won the half-mile event in the 1891 National Amateur Athletic Association competition.

Raymond J. Forkey '40, WPI's first 12-letter athlete and one of the leading punters in New England during his college days, threw four game-winning touchdowns during the undefeated 1938 season.

Earl M. Bloom '55, the leading scorer on the undefeated 1954 football team, received 15 varsity letters in four sports, the most ever earned by a WPI athlete.

Fidele L. DiPippo '60 was the first 1,000-point scorer in basketball.

Cary A. Palulis '68 won the 880-meter event in both the New England and the Eastern Championships three different years. He won 89 of his 91 races over his WPI career and still holds the WPI record for the 880 and the mile relay.

Alan K. Briggs '76 was WPI's first track and field All-American. He holds the WPI record for the mile.

David J. Wilson '80 was the first WPI wrestler to earn All-America honors. He was an All-New England wrestler all four of his WPI years.

Suzanne Call Margerum '81 was selected to the All-America Swimming Team three of her four years. She smashed nine of WPI's individual and team records.

Terese M. Kwiatkowski '83, who was named to the U.S.A. Field Hockey Division III All-Star Team in 1982, was the first WPI basketball player to score 1,000 points in just three seasons. With 1,400 career points, she is still the all-time leading scorer in WPI basketball history.

With Patricia Graham Flaherty '75, then president of the Poly Club, are the 1986 inductees, (from left) Merl Norcross, Cary Palulis '68, William Asp '32, Peter Horstmann '55 and Michael Walker '78.

The Games of Life

By Ruth Trask

During their four years on campus all WPI undergraduates must fulfill a physical education requirement, often by learning sports—like tennis, bowling or golf—that they can continue to enjoy long after they graduate. In addition, during the course of any given year more than two-thirds of the Institute's students take part in extracurricular athletics programs. For many, these experiences on the field, on the court, in the gym and in the pool nurture a love of sports and physical activity that will endure for the rest of their lives. For a special few, sports and athletics become something more—vital components of their lives and careers. In the pages that follow we present the stories of four alumni and one WPI family for whom athletics have become a lifelong fascination.

Jay Feenan Keeps Rowing Against The Tide

JANET WOODCOCK

Jay Feenan plies the waters of the Merrimack River near Lowell, Mass., in a one-man scull.

Among world championship athletes, it's often said that you're over the hill at 30. But don't tell that to James "Jay" Feenan Jr. '80. Last summer, at the age of 31, Feenan made the U.S. National Rowing Team as a spare oarsman, then went on to compete in the World Rowing Championships in Yugoslavia. He was the second oldest rower on his team, he says, and was probably the only one with a wife and three children.

Although Feenan got into the action last year only when one of the regular oarsmen was unable to compete, this year he's determined that things will be different. "Next time I'll row instead of just sitting as a spare," he vows.

Feenan's word is not to be taken lightly. The personification of determination, he's capable of making the seemingly impossible, possible. He failed to make the national team as a student in 1979, when he rowed with George Wespi, John Tracy and Fran Madigan, all members of the Class of 1979. (As a team, the four won the bronze medal in the lightweight four at the 1979 nationals, finishing behind the U.S. and Canadian national teams.) Most competitors would have hung up their oars for good, but not Feenan. He tried again ten years later and made it.

"I'm in better physical shape now than I've ever been in my life," he reports. Proving his point, Feenan practices at every opportunity, rowing out of the Merrimack River Rowing Association in Lowell and the Boston Rowing Center, where he is coached specifically for national team competition.

Feenan started rowing after a short-lived career as a junior varsity kicker on the WPI soccer team. Not enjoying picking up pine splinters on the sidelines, he turned instead to crew. "I did all right, too," he says, "despite the fact that some of my friends contended that I didn't have both oars in the water."

Feenan rowed for the varsity team from 1976 to 1980. In 1981 he attended the famous Henley Regatta in England. From 1981 to 1983 he coached crew at WPI with Dave Ploss '70 and Bob Nyce. After his coaching stint was over, he accepted a post as a software engineer for Digital Equipment Corp. in Nashua, N.H. For three years he was away from rowing, but he kept himself in good condition.

Rowing stayed in the back of Feenan's mind and in 1984 he once again took up the oars, ultimately training long hours to make the 1989 national team. This time he turned to sculling (rowing with two oars instead of one). Since he can now row a single-man boat, he doesn't have to coordinate other people's schedules to meet his.

"I started rowing again just for fun, but each year I improved a level. Originally I competed in just a few local races. The next year I began winning those races. Later, I competed in and won national events. During the past two years I've won two gold medals and a silver medal in national championships, as well as the lightweight single event at the Canadian Henley—the biggest rowing event in North America. Currently I rank as one of the fastest lightweight scullers in the country—and I'm still having fun!"

Balancing extensive competitive training with a full-time job and family can be tricky, according to Feenan, who says that all three are very important to him. "It's the rowing that keeps me sane," he says.

Following his return from the World Championships last summer, Feenan had a busy fall. He finished second in the Green Mountain Head (heavyweight single) competition in Putney, Vt., and also copped a second place finish in the Head of the Connecticut's open singles lightweight division. The grand finale was winning the championship double event in the prestigious Head of the Charles.

Feenan says that all competitive rowers need three things: good training partners, good coaches and the right attitude. "Competitors have to have confidence," he says. "I'm naturally confident—perhaps some people would think arrogant. I know that I have the ingredients to row."

Feenan says good upper and lower body strength is necessary in the successful rower's makeup. "Most races I compete in are 2,000 meters," he says. "It may look easy from the shoreline, but the oarsman is rowing much harder than he appears to be. A 2,000-meter race is like doing a series of 100-yard dashes for a mile with no rest."

Feenan starts his races at 38 strokes per minute, then goes down to 34, and up again to 40. "The trick is putting the oars in and out without disturbing the water. If you rile it up, it's like dragging your shoe while running."

Seven days a week, Feenan is out on the river, putting his theories into practice. He's got his eye firmly on making the national team and rowing up a storm at the World Rowing Championships in Tasmania, Australia. No matter what happens, though, Feenan will be making history. You see, this spring he turned 32.

Wrestling's All In the Family For Those Wonderful Wyman Boys

A Wyman family album: Todd wrestling in Alumni Gym in 1989 (above). Paul (at left) and coach Phil Grebinar with Toby after a recent win (below).

If anyone ever compiles a list of athletic family dynasties at WPI, the Wymans of Bridgewater, Mass., will be right up there on top. In the veins of brothers Paul '85, Todd '89 and Toby '91 flows the blood of champions.

Former wrestling stars at Bridgewater-Raynham Regional High School, the trio added even more luster to their reputations at WPI with stellar achievements in New England and national competitions. (A fourth Wyman brother, Peter, wrestled in high school, but decided to play football instead after enrolling at Bates College.)

"The Wymans are a real family of champions," says Phil Grebinar, WPI's wrestling coach, who notes that it was due in large part to the Wyman prowess that WPI won the New England Wrestling Championship in 1985 and 1987.

Paul, now a mechanical design engineer at Raytheon in Sudbury, Mass., started the ball rolling by capturing the New England Wrestling Association title in 1985. That same year, as an All-American, he wrestled for a national collegiate championship in Illinois. During his WPI career he notched a dual-meet record of 49-8. Paul now lives in Clinton, Mass., with his wife, Mary Park Wyman '84.

Last year, Todd, now operations manufacturing engineer at General Electric Company in Louisville, Ky., finished with a dual-meet record of 25-9. He placed third in the New Englands in 1987 and fifth in 1988 and 1989. He was named an NCAA Scholar All-American during the 1986-87 and 1987-88 academic years.

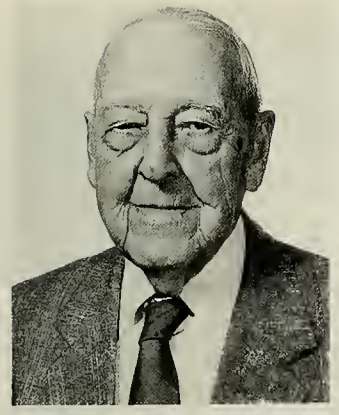
Following in his brothers' footsteps, Toby, now a junior at WPI, was recently named NCAA Scholar All-American for 1989-90. He has twice chalked up second-place finishes in the New Englands and placed fourth another year. His dual-meet record is 32-8-1.

As members of the Massachusetts Interscholastic Wrestling Officials Association, all three Wyman brothers actively referee high school meets. Paul, a New England collegiate referee, has served as assistant coach at WPI since 1987.

According to Toby, his parents, Arthur and Diane Wyman, have been instrumental in their sons' success on the wrestling mat. "They attended virtually every meet in which we took part in high school and in college," says Toby, adding that whenever two sons were wrestling on the same day at different locations, his parents would split up to cover both meets. "They have always been our biggest boosters."

Coach Grebinar, ecstatic over the Wyman brothers' winning ways and their contributions to the WPI wrestling team, says that Arthur and Diane have to be pleased with what their sons have accomplished on the wrestling circuit. "What a gene pool," he jokes. "I keep asking them when they're going to have more sons because I could use a few more good wrestlers."

The Wymans' loyal support of their sons, and of the sport of wrestling in general, has not gone unnoticed. In March of this year the couple were inducted into the Massachusetts Interscholastic Wrestling Association's Hall of Fame.



The Ice Man Cometh: The Story of Milton Garland

Love ice hockey? All that checking? The hat tricks? The occasional "differences of opinion?" If so, you may not realize how deeply in debt you are to Milton W. Garland '20, a longtime consultant of Frick Company in Waynesboro, Pa. In conjunction with Frick, Garland, a pioneer in refrigeration, designed and developed some of the first commercial ice rinks in the U.S.

Garland is responsible for developing rinks from Maine to California. For example, he was involved with the Bangor (Maine) Recreation Center rink and the Burlingame Ice Skating Club's facility in Belmont, Calif. In addition, to name just a few, he was associated with the development and construction of rinks at Williams College, Boston College, Dartmouth College, Princeton University, Cornell University, Colgate University, Ohio University, Pennsylvania State University, and Brown University. Other rinks that bear his stamp are at the Broadmoor Hotel in Colorado Springs, at Gimbel's in Philadelphia, at Virginia's Hot Springs Inc., and at recreation areas in New Brunswick and Ontario, Canada.

Garland has been concerned with the development of refrigeration compressors for industrial and commercial uses since receiving his bachelor's degree in mechanical engineering from WPI. He joined Frick, a manufacturer of industrial refrigeration equipment, as an erecting engineer trainee in 1920. He was later promoted to superintendent of field erection and chief engineer. He retired at 71 as vice president for technical services in 1967. Now 95, he continues as a senior consultant for Frick and walks several blocks to his office in Waynesboro, Penn., every weekday.

Innovations by Milton Garland (top) contributed to the success of a long and diverse list of ice skating rinks, from the hockey facility in Cornell University's James Lynah Hall (middle) to a portable rink set up in Gimbels department store in Philadelphia in 1959 (bottom).

In his "second career," Garland has organized the company schools for workers who service Frick equipment throughout the industry. "I've often been the sole faculty member for the 3,800 students and graduates of the course," he says.

A tribute that meant much to him was the establishment by Frick in 1972 of the M.W. Garland Scholarships. These provide partial scholarship support to children of employees who major in engineering or business programs at four-year accredited institutions. A lifetime member of the President's Advisory Council, Garland last year established his own WPI scholarship fund.

Early in Garland's seven-decade-long career he helped breweries convert to nonalcoholic product lines during Prohibition. When Prohibition ended, he showed them how to convert back to brewing beer. He also helped create the frozen food industry, worked on the liquefaction of natural gas, and assisted in the development of refrigeration technology for Padre Vineyards in California. Along the way he earned 37 patents, either singly or with others.

In 1988 Garland received the F. Paul Anderson Award for Scientific Achievement from the American Society of Heating, Refrigerating and Air Conditioning Engineers. The award, ASHRAE's highest honor, recognizes lifelong contributions to the advancement of environmental technology. In 1971 he received ASHRAE's distinguished service award. For his many achievements, ASHRAE has honored him with the unofficial title of "Mr. Refrigeration."

Garland shows few signs of slowing down. He credits his longevity to doing what he likes and taking care of himself. At 95 he is still an avid weekend golfer. "I'm also a licensed aircraft pilot," he says. "The only reason I'm not flying is that there's no liability coverage available for pilots over 75."

Paul Keating Takes the Soviets Out to the Ballpark

(From left above) Keating; Stump Merrill, manager of the New York Yankees; Vladimir Bogaterev, chairman of the U.S.S.R. Baseball Federation; an interpreter; Victor Pianych (in the Kansas City cap), assistant coach of the U.S.S.R. National Baseball Team; Alexander Ardatov, head coach of the national team; another interpreter. (Below) A souvenir of the Soviet trip.

If baseball eventually becomes a truly competitive Olympic sport, part of the credit can be laid at the doorstep of Paul J. Keating '64. The CEO of a large concrete and paving company, Keating is also the owner of the Yankee Double A franchise in Albany, N.Y., and the first chairman of the World Baseball Association, a new nonprofit group that promotes the game internationally.

Keating is no mere figurehead in the world association. Last summer he personally rounded up 20 Eastern League Double A players, 35 coaches and several umpires, cameramen, sports writers and baseball executives and flew them to the U.S.S.R. to teach the Soviets the finer points of America's pastime.

The Americans had their jobs cut out for them, Keating says. "We discovered that the Russians are eager to learn. Baseball is America's top game, and Soviet youths are drawn to it like rock 'n' roll. At the moment, however, they are running around with cheap Cuban gloves and a bagful of aluminum bats. It will take them at least 15 years to absorb the game and all its nuances."

The players and coaches made stops in Kiev, Tallinn and Moscow, and put on daily clinics for Soviet club players trying to improve their baseball. "Because of the language barrier, it was difficult to teach," Keating says. "When we tried to show them the wrong way and the right way, we learned we had to preface the wrong way with 'nyet' or they got very confused."

With the aid of an interpreter who didn't understand the game himself, the players had a rough time explaining such details as the balk rule to their pupils. "When it comes right down to it," Keating laughs, "there are plenty of Americans who don't understand the balk rule either."

In spite of language difficulties and inclement weather, the Americans persevered. They played games in soccer stadiums on windy, 30-degree days before curious crowds of a thousand. And they patiently taught their pupils the fundamentals of the game, such as touching the inside of second base with the left foot while heading for third.

"After blowing away the Soviet clubs in several demonstration games, we switched to the unity concept," says Keating. "The games were closer when we put a few Americans on each side."

According to Keating, the Soviet Union would like to be competitive in the Olympics and America wants the Soviets to learn the game to spur the international movement. He says that there are 33 gold-medal sports, but a hosting country has to guarantee to provide only 26. "If the Soviets become good at baseball, that would ensure baseball's spot in future Olympics," he says.

Like most minor league baseball road trips, there were plenty of laughs, surprises and hardships along the way. "Russia has a 1955 economy," Keating explains. "Accommodations were far from plush, and the food didn't always agree with us. But we managed to make our own fun."

For example, one night the manager of a Soviet club—a former Red Army officer—had the visitors over for dinner. "The Russians love vodka, and this guy loved to toast," Keating says. "So we toasted everybody from President Bush to Gorbachev. One of our coaches had a pitch counter with him, and gave it a click after every toast."

There were reportedly 87 "pitches" thrown down that night, and the Americans felt the effects of the toasting the next day at the clinic. "After a night like that, do you know how loud a ball hitting an aluminum bat sounds?" Keating asks.

Before their two-week tour ended, the Americans told the Russians they should introduce their kids early to baseball through Little League and Babe Ruth League. They need to build a pool from which to draw young talent, Keating says.

"At the moment most of their players are teenagers who didn't quite make the Olympic teams," he explains. "They turn track team members into center fielders, handball team players into infielders, and—would you believe?—javelin throwers into pitchers. It's tough to teach baseball to 19-year-old beginners borrowed from other sports."

To Skiers, Bucky Kashiwa Is the "Man Of Steel"

COREY KASHIWA

Bucky Kashiwa shows off his steel-encased Volant, the first stainless steel ski ever put into production.

Looks like the steel ski is here to stay. Bryan "Bucky" Kashiwa '73 invented it. Volant Ltd. of Boulder, Colo., is promoting it. And the public is snapping it up. "In our second year of production we are offering four models and have a volume of almost 8,000 pairs," reports Kashiwa.

Kashiwa, who studied mechanical engineering at WPI, says the secret of the ski's success is its unique design. Retailing for about $460, the revolutionary ski, known as the Volant (the word means "capable of flying" or "quick and nimble"), has a patented stainless steel casing that covers a laminated wood core and a fiberglass support strip. "Volants are the first stainless steel skis ever put into production. Not only do they perform well, they're practically bullet proof," Kashiwa says.

"My approach is to produce a ski with the fundamental qualities that all skiers require—regardless of their ability level," he adds. "The Volant provides ease of turning, good edge grip and good stability. These are the ABCs of any ski's performance. In my book, if the ski fails in any of these three areas, it's not of much value for general use."

A lifetime skier, Kashiwa was raised in the Adirondack Mountains of New York, was a member of the ski team at WPI, and was good enough to compete on the professional tour in 1976 and 1977. He's also the younger brother of Hank Kashiwa, a longtime member of the U.S. Ski Team and the 1975 World Pro champion.

After graduating from WPI, Bucky Kashiwa began a six-year post as a designer for American ski maker K-2. His forte was the classic slalom ski and several of his designs are still in production. He also developed skis for Phil and Steve Mahre, the bemedaled U.S. champion racers. After leaving K-2 in 1979, he received his Ph.D. in mechanical engineering from the University of Washington and became a research scientist at New Mexico's Los Alamos National Laboratory, where he now studies computational fluid dynamics for the U.S. Department of Energy.

As early as 1980 Kashiwa started dreaming of developing an aerodynamic steel ski. In 1983 he and Hank incorporated Golden Oak Research to fund the basic development of the ski and to pursue the patents for the design. The firm is funded by several shareholders, including former Olympic ski champion Jean-Claude Killy, who slope-tested early prototypes; Jon Allsop, designer of the "shock-absorber" ski pole; Mike Markkula, a founder of Apple Computer; Arthur Rock, a well-known venture capitalist; and Robert Noyce, a founder of Intel Corporation, the giant computer chip maker.

To get the ski to the marketplace, the Kashiwas enlisted the aid of an old friend, entrepreneur/promoter Jack Beattie, the younger brother of TV sports commentator Bob Beattie. Beattie helped develop Volant Ltd., which manufactures and markets the ski worldwide.

"This is the first real technological change in skis within the last 15 years," says Beattie, now president of Volant. "The ski is so flexible you can actually bend it into a semicircle." Hank Kashiwa, who snow-tests Bucky's inventions, says, "It's the best powder ski I've ever skied on. My brother's a pretty smart guy."

It's one thing for those with a vested interest to sing the praises of their product, but quite another when a critical buying public puts the product to the acid test. So far, the Kashiwas and Beattie have found acceptance of the Volant to be exceptional. The likes of Reider Wahl, 1983 World Pro Ski Champion and a former NASTAR Pacesetter, Jim "Moose" Barrows, one-time U.S. Ski Team Olympian, Bud Palmer, national network broadcaster, and Jackson Hogan, equipment editor of *Snow Country* magazine, have offered rave reviews. *Ski Tech* magazine tagged the Volant the most interesting new product of 1989.

Getting the Volant to market required overcoming a few obstacles. For example, Kashiwa solved an early problem in the metal-bending operation by designing a hydraulically run metal-bending machine. In 1989 he patented not only the ski, but the manufacturing process. In the next six months he expects that Volant will have six European patents.

As for the future of Volant, Beattie predicts that within 10 years the company will be making 50,000 pairs annually and posting $11 million in sales. On the horizon is the possibility of making small refinements that could transform the Volant into one of the fastest downhill skis in the world.

Still, Kashiwa says he won't go back to ski design full time. Instead he plans to stay at Los Alamos and tinker on the side, rebuilding his Volkswagen bug and doing some woodworking. "I enjoy using tools," he says. "Of course, I'd enjoy seeing my new toy, the Volant, get used, too."

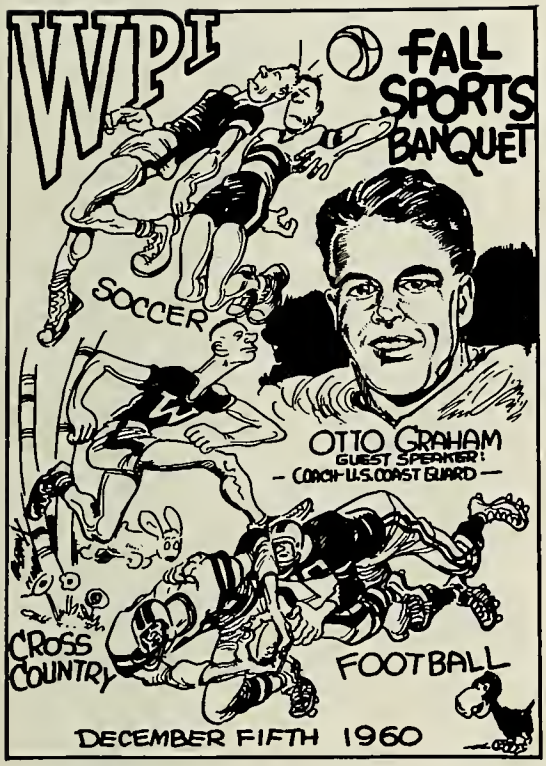
Through The Eyes Of Al Banx

By Michael Dorsey

WPI athletes and coaches were frequent subjects of the late cartoonist.

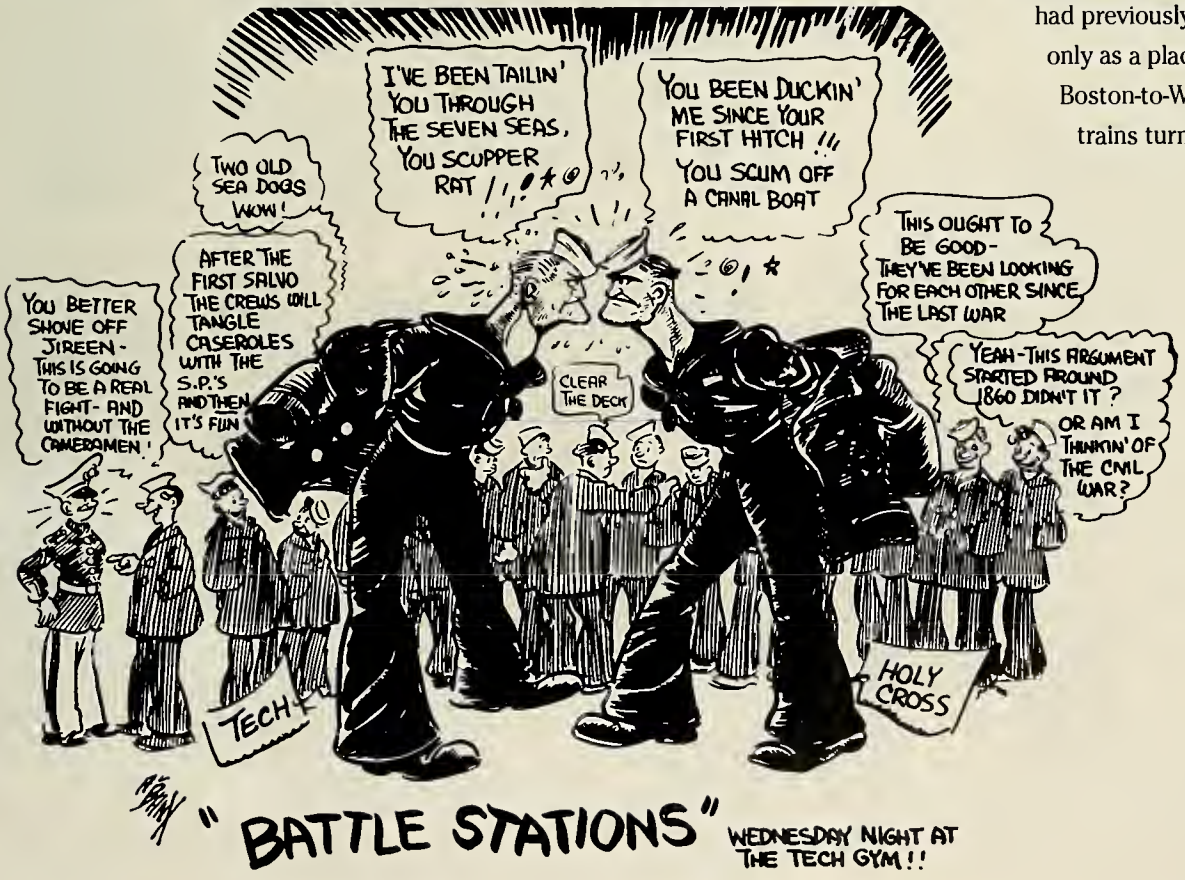
He was "everybody's cartoonist," the portly, cigar-chomping artist who kept Worcester's citizens—from the high and mighty to the common man—laughing at themselves for more than 40 years. As cartoonist for the city's two daily newspapers, Al Banx delighted central Massachusetts several times each week with panels packed with action, wry commentary and a motley cast of characters—from Lenon D. Bar, a political hanger-on, to the cat lovers of Uppah Burncoat. His humor had the gentle bite of satire, but it never stung. "He never made an enemy," noted the headline above an editorial written about Banx after his death.

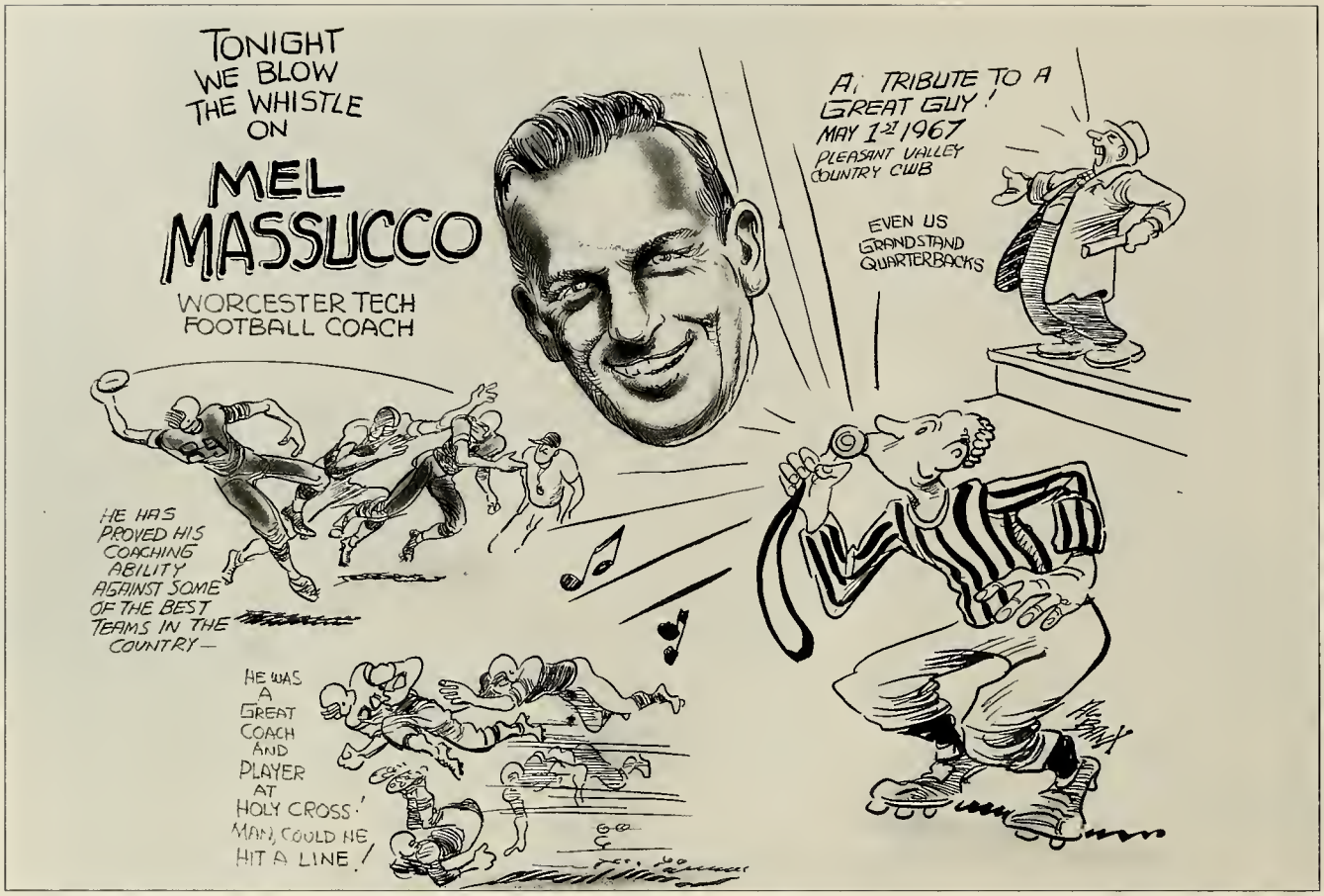
Al Banx had a special fondness for sports. His first cartoon for *The Evening Gazette* ran on the sports page and from then on at least two of his weekly drawings focused on the exploits of the city's high school and college athletes and coaches. Many WPI alumni recall the time they starred in a Banx original. He coined the nicknames for many area teams—the parrot known as Poly Tech (at left), which today is the mascot of WPI's Poly Club, was a Banx creation.



Banx, above, created special cartoons for WPI sports banquets (left) and featured WPI in many of his regular panels. The cartoon below highlighted a basketball match-up between WPI and Holy Cross in 1943-44, the first meeting between the schools in 25 years. WPI won, 55-47.

Banx was born James A. Banks in Boston in 1900. He served with the Marines in World War I and attended art school upon his return. After a brief stint with *The Boston Globe*, he joined the staff of *The Evening Gazette* in Worcester, a city he said he had previously thought of only as a place where the Boston-to-Worcester trains turned around.





One of several cartoons Banx drew for the WPI Alumni Association (right). Banx's last work was a gift for Mel Massucco (above), who was leaving Holy Cross to become WPI's head football coach.

His service with the Marines left him with a soft spot for U.S. servicemen. During World War II he wrote a regular column in the *Gazette*, "Banx to the Yanks," that brought local men and women serving overseas up-to-date on goings-on in Worcester. He also wrote many long letters to servicemen who "needed an extra letter from home." During the Korean War he toured air bases with a group of cartoonists led by Milton Canniff, creator of "Terry and the Pirates."

Banx died unexpectedly in his sleep in 1967. Worcester, which had heaped honors and awards upon him by the bushel during his lifetime, memorialized him in death. The Worcester Public Library dedicated an exhibit room in his memory and St. Luke's Church installed a stained-glass window made up of his illustrations of the Gospel According to Luke.

Banx's last cartoon, drawn on the day of his death in 1967, was of Mel Massucco, who had just become head football coach at WPI after spending a number of years as a student-athlete and a coach at Holy Cross College.

Timeline

A Journey Through WPI's First 125 Years

By Neil Norum

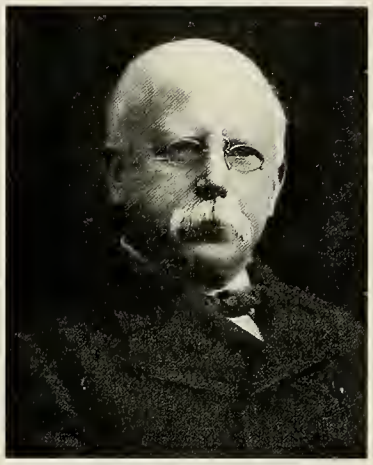
Third of Four Parts —The 1890s

The end of the 19th century was a time of turmoil around the world. The colonial powers of Europe were divvying up the continent of Africa. Japan defeated China in a brief war and, later, Britain and Germany annexed portions of the Chinese mainland. In 1900 an international force that included soldiers from the United States helped put down the Boxer Rebellion in China, a revolt against foreign intervention.

The Franco-Russian Alliance of 1893 split Europe into two opposing camps. The U.S. declared war on Spain over Cuba on April 25, 1898; a few days later Admiral Dewey destroyed the Spanish fleet in Manila Harbor. The war ended before the year was out and, as victor, the U.S. demanded its spoils: Cuba, Puerto Rico, Guam and the Philippines. As the decade neared its end, the Boer War flared in Africa.

There were a few rays of hope during those turbulent ten years. The first Hague Peace Conference opened in 1899, and the first modern Olympic games were held in Athens in 1896. American James Connolly, competing in the triple jump, won the very first gold medal.

The 1890s was also an age of scientific discovery. The elements argon, krypton, helium, neon, polonium, radium, radon and xenon were discovered. Wilhelm Rontgen discovered X-rays, Joseph Thompson identified the electron, and Ernest Rutherford detected alpha and beta particles emanating from radioactive materials. Max Planck formulated his quantum theory and the world of archeology was buzzing about Dutch scientist Eugene Dubois' discovery of Java man.



WPI's third president, Thomas Mendenhall.

Technological advancement was another watchword of the period. In the 30 years following 1875, the number of patents granted in the U.S. tripled; patent grants quadrupled in Germany. The World's Columbia Exposition opened in Chicago in 1892. The fair, which marked the 400th anniversary of the discovery of America by Columbus, testified to the technological progress being made in the New World. Among the mechanical marvels on display were the first Ferris wheel, an automatic moving sidewalk, and long-distance phone lines that connected Chicago with New York. Fairgoers also sampled a new treat called Cracker Jack and dined in the world's first cafeteria.

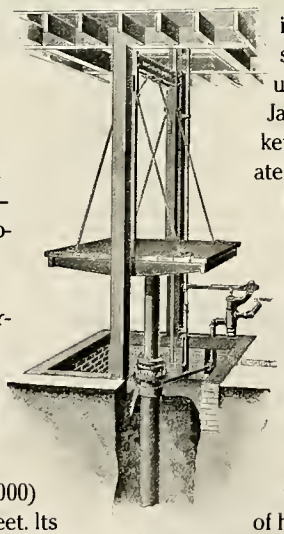
Automotive pioneer Elwood Haynes (insert), Class of 1881, and his first horseless carriage, now in the Smithsonian Institute collection.

During the 1890s Henry Ford built his first automobile and German engineer Rudolph Diesel patented his internal combustion engine. Charles and Frank Duryea built their first gasoline-powered vehicle in 1892 and began manufacturing horseless carriages in 1896 in Springfield, Mass. Elwood Haynes, WPI Class of 1881, was also a pioneer in the development of the automobile. His first horseless carriage was later acquired by the Smithsonian Institute. By 1899 more than 300 companies were producing motorcars or parts for the 4,000 vehicles then in use.

Other milestones of the decade included the first flight of Count Ferdinand Zeppelin's airship, the introduction of the first telephone with a dial, the inauguration of the first automatic telephone

The campus in the 1890s (above). In 1896, at the urging of President Thomas Mendenhall, the Washburn Shops ceased commercial operations, including sales of hydraulic elevators (below, left).

switchboard, the invention of the motion picture camera, the first magnetic sound recording, the invention of radio telegraphy by Guglielmo Marconi, the perfection of the adding machine by William Burroughs, the creation of the safety razor by King Gillette, and the invention of the zipper (this new fastener was not put into practical use until 1919, however).



Construction began on the Trans-Siberian Railway in the 1890s and the first hydroelectric station opened at Niagara Falls—a major milestone in the development of commercial electric service in the U.S. In medicine, doctors at Johns Hopkins University were the first to use rubber gloves during surgery and the bacteria responsible for causing plague, malaria and dysentery were discovered.

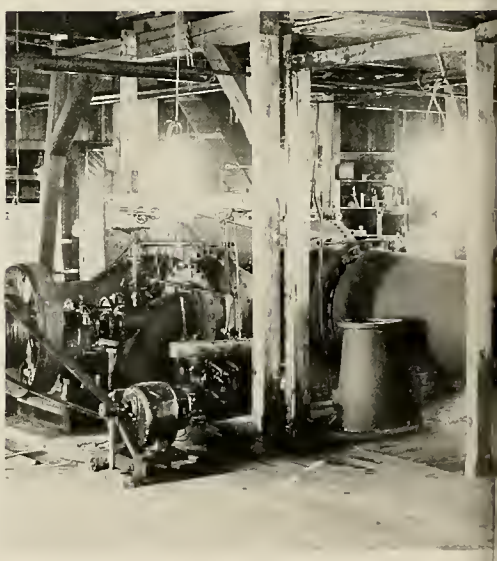
In 1897 Worcester (pop. 120,000) built a new city hall on Main Street. Its citizens were beginning to realize the benefits of electricity, as power lines were strung around the city. The lines reached Boynton Street near the WPI campus in 1891. By 1898, horse-drawn public transportation was being replaced by electric trolleys.

Elsewhere in the U.S., in 1890 the Seventh Cavalry massacred 153 Sioux Indians (including leader Big Foot) at Wounded Knee, and the Sherman Antitrust Act was passed to break up monopolies. The following year the Forest Reserve Act set aside forest lands for public use. In Springfield, Mass., Dr. James Naismith hung peach baskets from a gym balcony and created the game of basketball. Ellis Island opened its doors to immigrants and, during its first year of operation, more than 7,000 filed through the way station each day. Immigration boosted the U.S. population from 63 million to nearly 76 million during the 1890s. In one of the decade's more celebrated crime stories, Lizzie Borden was acquitted of the ax murder of her father and stepmother in New Bedford, Mass.

The depression of 1893 resulted in the failure of 600 U.S. banks, 74 railroads and more than 15,000 commercial businesses. It was the worst depression in U.S. history to that point. In 1894, a year marked by strikes by coal miners and workers at the Pullman Palace Car Company in Chicago, President Grover Cleveland made Labor Day a national holiday.

Before the decade was out, the Hershey Bar was developed and Sears, Roebuck & Company started its mail-order business, Adolph Ochs bought the failing *New York Times* to combat the "yellow journalism" of publishers Randolph Hearst and Joseph Pulitzer, and an editorial writer at *The New York Sun* answered a little girl's letter with an essay that contained the now classic line "...yes, Virginia, there is a Santa Claus."

"The present must be regarded as a critical period in the history of the Institute,"



said a WPI Alumni Association pamphlet of 1895. During the next 20 years the Institute would raise its standards and standing to levels previously thought impossible.

Having been christened the Worcester County Free Institute of Industrial Science, John Boynton's college was renamed Worcester Polytechnic Institute in 1886. The change was appropriate, for the end of the century would mark WPI's transition from a technical school to a true college of engineering and science.

Among the new facilities added during the term of President Homer Fuller was the hydraulic laboratory in nearby Holden (below).

In 1887 WPI's enrollment passed the 150 mark, with two-thirds of those students hailing from Worcester County. This success presented the college with a challenge. Having once offered free enrollment to county residents, WPI found that the income from John Boynton's founding gift would provide sufficient funds for fewer than 40 students. The rest would have to pay a tuition of $150.

The *Aftermath*, only the third yearbook in the Institute's history published by students, appeared in 1891. Its portrayal of certain faculty members was considered scandalous and its editors received their diplomas only after they apologized for their transgressions. The first student newspaper, the *WTI*, put out its first edition in 1885. The administration considered it frivolous, but the publication, renamed *WPI* in 1887, managed to survive until 1896, when it ceased publication due to a lack of funds.

The *WPI Journal* premiered in 1897. The first issue included a host of technical articles with such titles as "Rough Design and Estimated Weight of Scotch Boilers" and "Resistances, Rheostats and Electric Heating Apparatus." But the magazine had its lighter sections, such as Alumni Notes and The Institute. The first issue reported that the student body had grown to about 220.

Thousands of immigrants passed daily through the newly opened Ellis Island, swelling the U.S. population.

A bit of curricular reform attempted by the Institute in 1897 was thwarted when all the seniors studying mechanics signed a petition demanding that the senior course in shop continue to include work in the blacksmith shop. In October 1898 WPI established a new holiday, "Mountain Day," and students and faculty were urged to spend the day in the country.

Homer T. Fuller, WPI's second president, resigned in 1894 after 11 years at the helm. Speaking at graduation that year, he listed some of the accomplishments of his term. He noted that the college had abandoned the last of its apprentice courses and had

WPI began intercollegiate football in 1888. The Institute fielded this team in 1895.

launched a standard four-year course of study. Salisbury Laboratories was completed that year and the hydraulic laboratory in nearby Holden was launched.

Thomas C. Mendenhall, a noted scholar and administrator who had most recently served as superintendent of the U.S. Coast and Geodetic Survey, was named WPI president that year, just as the college was using funds provided by the Commonwealth of Massachusetts to build a new mechanical engineering building—rated among the best in the eastern U.S.—a power house, and a residence for the president. The state also began granting the Institute funds for scholarship aid, a practice that would continue until a new amendment to the state constitution, passed in 1917, ended regular grants to private colleges.

Mendenhall immediately created a dilemma when he asked, "Are we one educational institution with several branches or are we two institutions?" The question referred to two seemingly distinct educational programs taught in the classroom and in the Washburn Shops. Mendenhall wanted to ensure that the Institute was a seat of higher learning and not a trade school for apprentices. The new president's job would have been easier had the shops not been so successful.

In 27 years of operation the shops had sold nearly $1 million worth of products at a net profit of 15 percent. The WPI hydraulic elevator had been installed in every major U.S. city, and sales of plunger elevators, grinders and drill grinders were earning profits ranging from 7 to 41 percent. In January 1896 the Trustees voted to discontinue the elevator business and Milton Higgins, its superintendent, and George Alden, head of the Mechanical Engineering Department, left WPI to found Norton Company. From then on, the Washburn Shops would no longer be a commercial enterprise.

The WPI Alumni Association formally received its charter in 1891; by the end of the century it had branches in New York, Boston, Cleveland, Philadelphia, Washington, the western U.S. and the Pacific Coast. The Spanish-American War claimed its first victim from the college's alumni body when Lt. Edward N. Benchley, who had enrolled at WPI in 1893 and left shortly afterward to attend West Point, was killed on July 3, 1898, in the charge on San Juan Hill.

In 1891 the Institute also welcomed its first Greek fraternity, Phi Gamma Delta. The WPI chapter of Sigma Alpha Epsilon was founded in 1894. In the 1890s, students organized a host of new clubs and organizations, including the Washburn Mechanical Engineering Society, the student YMCA, the Current Topics Club, the Camera Club, Tech Elect (for students of electrical engineering), the Salisbury Sanitary Engineering Club, and the Musical Association.

WPI awarded its first graduate degrees in 1898. At Commencement the following year, held in the Boynton Hall assembly room, 25 men received undergraduate degrees and 10 were granted advanced degrees. The college began playing intercollegiate football in 1888. By the late 1890s the schedule included Colby, Rensselaer, Holy Cross, Tufts, and MIT.

In 1890, George Frisbie Hoar, U.S. Senator and one of the principal forces behind the founding of the Institute, summarized the state of WPI as the century approached its end: "We have sent out year after year from our classes young men who have been highly taught in the arts of life and who have become all over the country men of moment, who have helped administer great business transactions upon which the safety and prosperity...of the nation depended."

Solving Bangkok's Traffic Headache

Interactive Qualifying Project completed at the Bangkok Project Center by Shamim L. Hasan '91, Michelle J. Marcoux '91, and Thomas F. Walsh '91.
Advisors: Lance E. Schachterle, professor of English and associate dean of undergraduate studies, and John F. Zeugner, professor of history.

Think rush hour traffic is bad in your city? Think again. In Bangkok, where there are more drivers than the roads can handle, rush hour begins at dawn and lasts until dusk.

Once primarily agricultural, Thailand is becoming a modern industrial society, with a resulting increase in pollution and traffic congestion. In an effort to lessen both problems, two major Thai transit agencies have joined forces to build an elevated rail system in Bangkok. The system, scheduled to be running in 1995, will carry more than 19,000 passengers per hour.

(Left to right) Walsh, Marcoux and Hasan present their project findings in Bangkok.

Hasan, Marcoux and Walsh studied the potential impacts of the transit system, particularly air pollution, noise and vibration. They found that the system could lessen air pollution in Bangkok if the trains are powered by electricity, rather than diesel fuel, *and* if the public comes to view the new system as an attractive alternative to the cars and for-hire vehicles that now clog city streets.

They also found that the increase in noise caused by the trains should be negligible, since ambient noise levels in the city already exceed World Bank and World Health Organization standards. Still, they recommended that noise-reducing materials be used and that steps be taken during construction to minimize noise generated by the operation of the system. Similar measures should reduce vibration problems for residents who live within 40 feet of the railway.

Hasan (left) and Marcoux in front of the Golden Temple compound in downtown Bangkok.

Easing Pollution in Developing Nations

Interactive Qualifying Project completed at the Washington, D.C., Project Center by Athena Demetry '91, Matthew R. Henderson '91 and David L. Marshall '91.
Advisors: Thomas Keil, professor of physics, and Susan Vernon-Gerstenfeld, visiting assistant professor of interdisciplinary affairs and director of the Washington, D.C., and Ireland project programs
Sponsor: Office of Energy, U.S. Agency for International Development

Fossil fuels—coal, oil and natural gas—are being used at rapidly increasing rates to meet the world's power and transportation needs. But there may be a high price to pay for this progress, say Demetry, Henderson and Marshall.

The students looked at the health consequences of air pollution caused by burning fossil fuels in 13 developing countries: Argentina, Brazil, China, India, Indonesia, Malaysia, Mexico, Pakistan, the Philippines, South Korea, Taiwan, Thailand, and Venezuela.

Already, city dwellers in many of these countries are exposed to air pollution levels that exceed standards set by the U.S. Environmental Protection Agency. By the year 2000 fossil fuel emissions, which include sulphur dioxide, nitrogen oxides, carbon monoxide and lead, could cause serious health problems for residents of these nations, especially children, asthmatics and the elderly, the students found.

Adding fuel to the fire are population growth, rapid industrialization and the migration of large numbers of people from rural areas to cities, which are driving up the demand for energy. Already, frequent power shortages are common in some of the nations studied. To meet the rising demand, new power plants—generally fueled with coal, oil or gas—are rising, which may further degrade air quality.

The students recommended that the Agency for International Development

- help these countries develop programs to control fossil fuel emissions, and educate the public about their dangers.
- help make power plants and transmission lines in these nations more efficient and promote energy conservation. Energy not used or wasted, they note, is energy that need not be generated.
- promote technologies (scrubbers, filters, etc.) that make fossil fuel plants cleaner, and promote the use of cleaner fuels (natural gas and hydro power, for example) when feasible and cost effective.
- promote technologies that reduce emissions from vehicles.

"If developing countries continue to follow their current trends," say the students, "the air pollution and health impacts are likely to reach alarming levels."

—Bonnie Gelbwasser

Irving Gerber Carves Out A Brand New Lifestyle

For nearly 40 years Irving Gerber '44 of Belmont, Mass., an electrical engineer by education, served as a manufacturer's representative in the electronics field. Now retired, he is literally carving out a new life for himself—crafting custom furniture.

"It's really a labor of love," Gerber said in an interview with the *Belmont Citizen-Herald.* It soon becomes obvious that he didn't go into this line of business for the money. "One time I kept track of the hours I spent on a project and I calculated that I make about $1.25 an hour. All the same, if someone wants me to make a piece of furniture that I find interesting, I'll make it."

Gerber's favorite style of furniture is the Federal Period—the first half of the 19th century. He says modestly, "It doesn't sound very romantic to say I merely copy the style. But that's what I do." Copy, or not, Gerber must be doing something right. He has customers from as far away as Chevy Chase, Md., and Wilmington, Del., who appreciate his beautifully handcrafted pieces.

Gerber is not an untutored weekend carver who decided to make the big jump into furniture crafting. After his retirement, he studied furniture making for two years full time at the North Bennet Street School, located in Boston's North End. "I thoroughly enjoyed my time at Bennet," says Gerber. "The school draws students from all over the country. There was a mixed bag of interesting, delightful people."

Gerber's classmates included, among others, a fellow with a degree in medieval studies, a professional skier, several arts majors, and a couple of former Air Force pilots. Besides furniture making, the school trains students in other crafts such as bookbinding, jewelry making, preservation carpentry, piano tuning, violin making and locksmithing.

Gerber appreciates the fact that the Bennet's furniture making curriculum is structured to allow students to learn from their peers. "They admit three or four new students every few months," he says. "Everyone is at a different stage of learning, so a great deal of instruction is exchanged among the students themselves."

A swan carving from an Empire Period bed crafted by Gerber.

After two years of perfecting his craft at Bennet, Gerber set up shop with The Fine Woodworkers of Boston, which is located on the second floor of a converted textile mill in Charlestown. There, half a dozen furniture makers work independently and share the use of heavy tools. Although the drafty old building can get chilly in the winter months, it is warmed somewhat by the smell of cut mahogany, cherry and walnut, Gerber says.

In spite of the occasional polar working conditions, Gerber has no plans to follow the snowbirds south come fall. "My wife and I are doers," he explains. "She paints with oils and still takes lessons twice a week. And I enjoy hand crafting furniture too much to take time off."

Gerber says that about 80 percent of their friends live in Florida in the winter, and that he and his wife visit them occasionally. But they can't wait to get back to New England. "Everyone in Florida is hung up on cards and golf," Gerber says. "I'd rather work in my shop all day. Every day. Making furniture is a ball!"

—Ruth Trask

A corner chair carved in curley maple (above). Irving Gerber at work in his Belmont, Mass., studio (opposite page).

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Firesafety at Sea

Racing With the Sun

Making a Difference In Venice and London

WPI Journal

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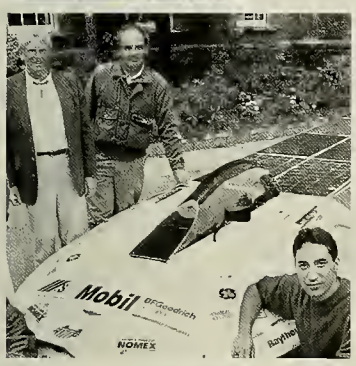

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Front Cover: The tanker *Mega Borg* burns in the Gulf of Mexico earlier this year. Story on page 4. AP/Wide World Photo. **Opposite:** The WPI campus not long after the Institute began classes in 1868. Story on page 21. Print from the collection of the American Antiquarian Society. **Back Cover:** Students climb the hill to the Washburn Shops after a late fall snow shower. Photo by Michael Carroll.

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A Pioneer in Marine Firesafety

In this issue of the *WPI Journal*, we feature the work of researchers who are applying state-of-the-art computational and computer modeling techniques to marine firesafety. Their efforts are helping to transform what has been for many decades a "seat-of-the-pants" operation—fire protection engineering—into a rigorous engineering discipline.

In focusing on the push to bring a more scientific approach to this important field, we do not want to neglect the contributions of the scientists and engineers—including many WPI alumni—who have made seminal contributions to firesafety and helped lay the foundation for the work being done today. When one looks back at the achievements of alumni in the firesafety field, one name stands out for special recognition.

The carrier *Franklin* takes a direct hit by a kamikaze. Nozzles invented by Howard Freeman '40 helped fight oil and gasoline fires on U.S. ships during World War II.

After graduating from WPI in 1940 with a degree in mechanical engineering, Howard G. Freeman became head of research and development for Rockwood Sprinkler Company in Worcester, founded in 1908 by George I. Rockwood, WPI Class of 1888, who was briefly a professor of steam engineering at the Institute.

Freeman established Rockwell's R&D department—consisting initially of just himself, but later numbering about a dozen engineers—and headed it for 14 years. In that time, he earned about 20 patents for significant developments in the field of fire protection.

Freeman turned his attention first to a seemingly mundane problem—improving the spray nozzles that were just then being developed for fighting fires. The need for technology of this sort would take on special urgency when the Japanese attacked Pearl Harbor in December 1941.

The U.S. Navy called on Rockwood and several other companies to find a new way to fight oil fires on ships. Using traditional fire-fighting methods, naval crewmen attacked the fires by directing streams of seawater at them. The technique was ineffective, and the Navy was losing too many ships to fire. Freeman traveled to Washington, D.C., with a Rockwood manager to hear about the Navy's problem. He quickly realized the work he was doing back in Worcester held the answer.

Within two weeks, Freeman worked out a design for a nozzle that could create a fog of water particles. The fog, Freeman knew, could extinguish an oil fire far more effectively than a water stream; it had the added advantage of shielding a fire fighter from the heat of the flames—enabling fires to be fought in close quarters.

The nozzle—named "Waterfog"—was evaluated at the Navy's test station in Norfolk, Va., where it worked exactly as Freeman had predicted. The Navy approved the design and sent Freeman back to Worcester to begin setting up a pilot production facility.

As the first units were coming off the line, the Navy called again. Off the coast of Nova Scotia the troop ship *Wakefield*—a converted passenger liner and the largest ship in the Navy's fleet—was ablaze. Rockwood rushed to complete enough nozzles to fight the fire and delivered them to the Quonset Naval Air Station in Rhode Island. From there they were flown to waiting destroyers and put to work successfully extinguishing the massive blaze.

During the war the nozzles Freeman designed would save not only dozens of naval vessels, but thousands of American lives, making this 23-year-old engineer a hometown hero. Toward the end of the war, Freeman was again consulted by Washington. The Navy fleet was facing a new threat—kamikazes. The nozzles that Freeman had designed were not proving effective against the gasoline fires that erupted as these manned bombs crashed on the decks of U.S. ships, and Freeman was asked to develop a device that could generate a fog of fire-fighting foam.

With no precedent to follow, Freeman relied on his own intuition and devised a combination of a special fog nozzle and a metal screen that "worked so well, it was unbelievable," he says. In short order, Freeman solved a problem that had puzzled the Navy's own researchers for several months. After the war, the nozzles were adapted for use on the crash rescue vehicles used at most military and commercial airports.

Despite his success, Freeman chose not to remain in the firesafety field—a profession in which one can never truly judge the success of one's inventions until there is an accident or a disaster. In 1954 he decided to start his own company to develop technology that could be put to work in everyday life. He left Rockwood and, in a laboratory set up in a bedroom in his home, developed a flexible seat for the ball valve that revolutionized the valve industry. His company, Jamesbury Corporation, would become one of the world's largest manufacturers of valves.

—Michael Dorsey

The Opening of the American Mind

Editor's Note: *The following is an excerpt from an address presented at WPI's Academic Convocation on Sept. 6, 1990.*

There are many critics today, most notably Allan Bloom, author of the recent best seller *Closing of the American Mind*, who are painting a gloomy picture of education in this country. I have never been high on the providers of doomsday oracles; I relate better to visionaries. However, it is important to assess our present situation before we can chart our course and set our compasses.

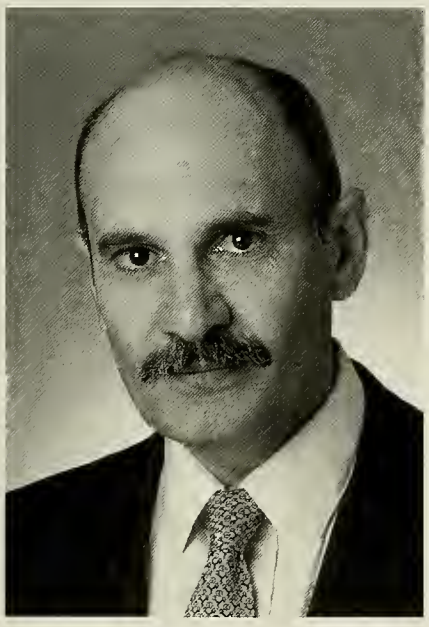
During the 1950s the U.S. enjoyed a market eight times as large as the next largest in the world. That has changed. On Jan. 1, 1993, when the members of the European Economic Community integrate, they will create a common market with 320 million people and a per capita income approximately equal to that of the United States. If they can convince Gorbachev to join in, that market will swell to about 620 million people, and the economic power of the United States will be diminished.

Equally troubling is the fact that we are putting only about 1.7 percent of our gross national product into nondefense research and development. For our principal competitors, Germany and Japan, that figure is between 2.5 and 2.8 percent. In 1988 and 1989, productivity in most industrialized countries grew more than five times as fast as it did in the U.S.

I don't want to curse the darkness. Instead, I'm asking our students to help us light the candles. How do we do this? I submit that there are five core issues we need to address:

1. Productivity

Our nation's work force possesses neither a world-class education nor world-class skills. Our high school graduation rate is down to 72 percent, while the rate in most of Europe is about 94 percent. The average American high school senior has about one-third fewer school hours under his belt at graduation than his counterparts around



Dr. Diran Apelian

the world. Clearly, our view of productivity does not compare favorably to the philosophy of our competitors around the world.

2. Knowledge is Power

T.S. Eliot said it so eloquently: "Where is the life we have lost in living? Where is the wisdom we have lost in knowledge? Where is the knowledge we have lost in information?" This is the Information Age, but we must remember that it is knowledge and wisdom that matter, not just information and data. It's sad to learn that only 6 percent of 17-year-olds can correctly answer this question: "If you have 10 coins, including one quarter, one dime, one nickel and one penny, what is the least amount of money you could have?"

3. Technical Literacy

In 1920 H.G. Wells wrote, "Human history becomes more and more a race between education and catastrophe." By and large, our educational institutions reflect—rather than determine—public perceptions, priorities and values. The state of U.S. education in mathematics, science and engineering is a reflection of a common misperception that only those preparing for technical or scientific careers need take significant course work in these areas. The absence of a strong national consensus on the importance of mathematics, science and engineering education for all citizens is one of our most pressing problems.

4. Thinking Globally

We have not lived in the world the same way the rest of the world has. Europeans have always had a counterculture haunting them. The French have been aware of the competition they face from Germany, England and Italy in a real way. We in the United States have not had a counterculture. To the east and west, we've got vast oceans; to the north, Canada; and to the south, Mexico. We must make it a national priority to be aware of the rest of the world and to be cognizant of the implications of the technological decisions we make.

5. A Sense of Identity

We have confused tolerance for a lack of standards with freedom. Each person, it is believed, should be free to do his or her own thing without recrimination, at least as long as no one else is directly injured. This philosophy overlooks the fact that such behavior only produces confusion; every society requires some important common standards and a common sense of identity. Every freedom has its price. We cannot know what desirable behavior is unless we have a sense of who and what we are. We need to restore an understanding of the human limits—something that a sense of identity and good character require.

We Americans have always been individualists, but we have also had a strong, common purpose at our core, and have relied on a common will and a shared culture. We need to rejuvenate and strengthen our national purpose. It is only in this way that the U.S. can regain its position as a world leader and a world-class competitor.

—Diran Apelian

Apelian is WPI's provost and vice president for academic affairs.

Fire On the Water

A sophisticated approach to firesafety developed by WPI researchers is helping the U.S. Coast Guard design safer cutters.

By Michael Dorsey

On March 30, 1979, the 674-foot cruise ship *Angelina Laura* was done in by an unattended skillet. When cooking oil in the skillet burst into flames, setting fire to a wall in the crew galley, it triggered a series of fire-fighting procedures that should have saved the ocean liner as it lay safely at anchor in St. Thomas harbor.

Instead, hampered by heavy smoke, the ship's crew and members of the Virgin Islands Fire Department watched helplessly as the fire spread to a nearby dining room and, from there, throughout the rest of the ship. Two hours and 15 minutes after the fire was first detected, the last of the fire fighters abandoned ship. The fire burned for four days before the ship finally listed and settled to the bottom of the harbor.

The *Angelina Laura* disaster was just one of dozens of major fires to strike ocean-going vessels in recent years. A fire that began in the hairdressing salon of the liner *Lakonia* in 1963 killed 125 people. A 1965 fire on the cruise ship *Yarmouth Castle* caused 87 deaths. In 1971 a fire on the overloaded Greek passenger ferry *Heleanna* took 24 lives. No lives were lost when the engine room of the miniliner *Prinsendam* caught fire during a cruise across the Pacific, but the ship itself was destroyed. This year a blaze on the passenger ferry *Scandinavian Star*, which killed about 170 people

JANET WOODCOCK

A firesafety method developed by Robert Fitzgerald (left), shown here with Coast Guard Lt. Roy Nash, a graduate student at WPI, is helping design safer ships.

on a run between Oslo and Copenhagen, and a spectacular fire on the oil tanker *Mega Borg* in the Gulf of Mexico have captured headlines.

Of all the misfortunes that can strike a ship at sea, fire is, perhaps, the most dreaded. Fighting fires in the narrow passageways and stairways of a typical vessel can be treacherous. Openings for wires, cables and pipes can allow flames to spread from compartment to compartment. Dense smoke, carried through the ship by ventilation systems, can make it difficult to approach fires or to evacuate passengers and crew. Should a fire grow out of control, a ship's crew may be forced to choose between staying on a burning vessel or taking to lifeboats—sometimes an equally dangerous option.

Over the decades, engineers, government officials and international conventions have worked to make ships less likely to burn, and to protect the lives of passengers and crew members when shipboard fires do erupt. Often driven to action by well-publicized disasters, like the sinking of the *Titanic* or the deadly fire aboard the *Morro Castle* in 1934, the marine firesafety community has, bit by bit, addressed problems in ship design, fire-fighting technology, and crew training and procedures. Much as their shore-based counterparts have done, marine fire protection engineers have formalized these new ideas into firesafety codes and standards. With time, as the codes and standards have grown more comprehensive, ships have grown increasingly safer. But this piecemeal approach to firesafety leaves much to be desired, says Robert W. Fitzgerald, George I. Alden professor of civil engineering and fire protection engineering at WPI.

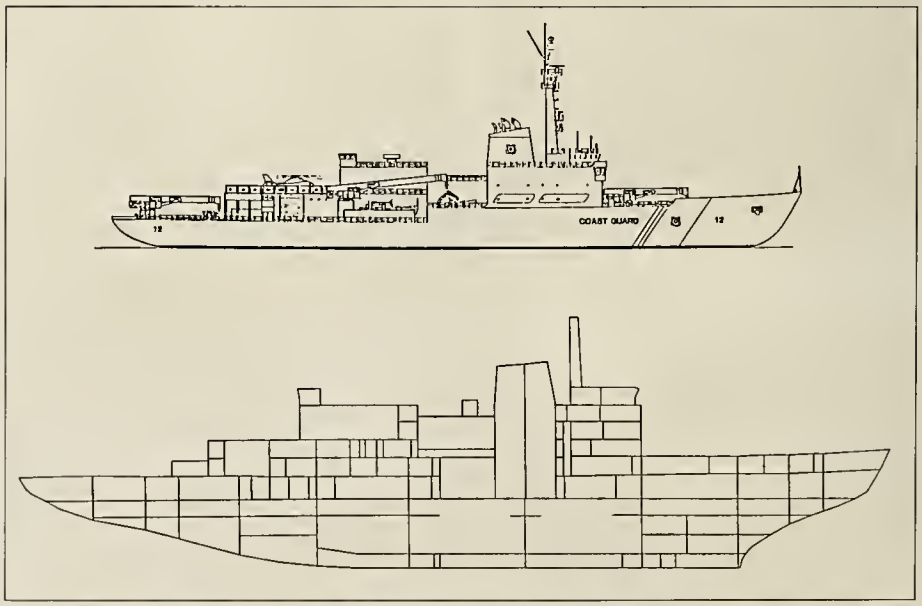
"Codes are based on judgment," he says. "A group of people sit around a table and agree on what the specifications should be, based on the anticipated conditions, their experience, and their best judgment. Because codes are not rooted in theory and experimentation, they tend to be weak, technically. This doesn't mean they don't have value. It's just that they don't enable you to quantify safety—to predict performance and identify rationally an acceptable level of risk. You can design a ship that complies fully with the codes, but that doesn't mean you'll know how safe the ship will be."

Over the course of more than a decade, Fitzgerald has developed a methodology that approaches firesafety from a different direction. Beginning with the assumption that fires will occur in any type of structure, the methodology (which Fitzgerald calls an engineering framework) asks, what is the likelihood that the fire will become established and spread? Using the techniques of risk analysis, operations research, systems analysis and decision analysis, the method enables engineers and designers to ask "what if" questions: what if the amount of combustible material in a room is reduced?; what if automatic fire suppression systems are installed?; what if the walls or ceilings are made of more fire resistant materials?; what if different fire-fighting techniques are employed? These questions can improve the odds that structures—and their inhabitants—can survive a fire, that property will be protected, and that structures will continue to function effectively after a fire.

Fitzgerald's technique, originally developed for buildings, is now being adapted to help design safer ships. It is one of several innovative approaches to marine firesafety being pioneered at WPI in conjunction with engineers in the United States Coast Guard.

Part of a research focus on firesafety in transportation (including roadway tunnels, mass transit systems and the space station) by faculty members and graduate students in WPI's 10-year-old Center for Firesafety Studies, the research on marine firesafety makes full use of the advantages of computer models and modern computational techniques. And, it is beginning to bring about what David A. Lucht, director of the firesafety center, calls "a cultural change in the way we design for firesafety."

WPI's involvement with marine fire-safety began in the early 1980s when Robert C. Richards, chief of the U.S. Coast Guard's Marine Fire and Safety Research Division, attended a short course at WPI on the evalu-



COURTESY U.S. COAST GUARD

The preliminary design for a new generation of polar ice breaker provided the Coast Guard with an opportunity to test Fitzgerald's marine firesafety method.

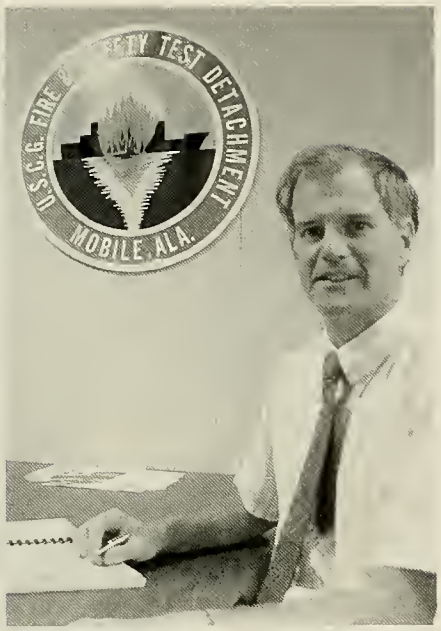
ation of building firesafety. Realizing that similar concepts could be applied to ships, Richards approached WPI in 1984 for help in addressing firesafety issues in the design of new Coast Guard cutters. Having completed a decade and a half of fire studies and fire tests—including full-scale fire tests on two retired merchant ships at its Fire and Safety Test Detachment in Mobile, Ala., the Coast Guard had become interested in developing a more comprehensive approach to firesafety on its ships.

"The Coast Guard's fire protection research efforts had been based on whatever the current interests were," Richards says, "and we'd approach things project by project. But we weren't necessarily putting our money where it would do the most good."

Working together, WPI researchers and the Coast Guard developed a modification of Fitzgerald's engineering framework geared to ship design. Fitzgerald says the framework was an outgrowth of work on fire protection he did in the early 1970s for the U.S. Office of Civil Defense—part of a major effort then under way by the agency to systematically address a wide spectrum of disasters—including earthquakes, floods, high winds and fire.

Fitzgerald authored the fire section of a major report published by the Civil Defense Office, a task that introduced him to the limitations of existing fire codes. He embarked on what eventually evolved into a new approach to fire protection that employs the methods and rigors of engineering analysis, rather than the legislated rules that form the heart of fire codes. His progress was accelerated when he teamed

MICHAEL DORSEY



WPI's marine firesafety work began with an idea of Robert Richards, chief of the Coast Guard's Marine Fire and Safety Research Division in Groton, Conn.

up with Rexford Wilson, a fire protection engineer in Wellesley, Mass., to develop a short course in firesafety for the University of Wisconsin.

Over the next decade, Fitzgerald and Wilson used the method as they taught their course to more than 2,000 students, continually revising and refining the framework based on its success in the classroom. "We found that our work often pushed us ahead of the current state of the art," Fitzgerald says.

Fitzgerald also got firsthand exposure to fire fighting as he worked to develop his methodology. During the past 16 years, he has gone into dozens of burning buildings with fire fighters from the Worcester Fire Department to observe the challenges they face as they do their jobs. The experience has enabled him to simulate more accurately in the framework how the design of a building affects the success of fire fighters, how various fire-fighting techniques work in different environments, and the advantages and limitations of various types of building features and fire-fighting hardware.

"In an analytical sense, there are similarities between fighting fires on ships and fighting fires in buildings," Fitzgerald says. "But it is usually a lot more difficult to maneuver on a ship. A ship's damage control team is not always as well-equipped or experienced as a typical fire department, and the heat, smoke and accessibility problems can be more severe."

As the methodology matured, Fitzgerald turned to the late Ramon C. Scott, associate professor of computer science, for help in translating the framework to the computer. Through dozens of projects by undergraduate and graduate students, Scott helped develop the algorithms that today make it possible for the method to be used in complex design applications. In more recent years, he worked with Fitzgerald to incorporate the techniques of artificial intelligence, expert systems, subjective probability and fuzzy logic into the method.

On paper, the version of the method that Fitzgerald and Richards have developed for the Coast Guard, known as the Ship Fire Safety Engineering Method (SFSEM), looks much like the flow charts computer programmers use to illustrate the twists and turns their programs can take, depending upon the conditions they encounter at each fork in their paths. Called a fault tree, the method progresses through a series of forks, each of which represents an important milestone in the development of a fire.

At each fork the fire can take one of two paths. Insufficient fuel, an automatic fire suppression system or the actions of human fire fighters, for instance, can prevent it from progressing, or the fire can advance to a new stage. The method has a host of factors and mathematical relationships built into it, which it uses to evaluate the probability that the fire will pursue either of the alternative paths.

For example, the method may begin with a specific compartment on a ship—say a crew berthing area. Based on reports of actual fires that have started in crew berthing areas on other military vessels over an extended period of time, the method determines the probability that something will

ROBERT FITZGERALD

To gather data needed to analyze the Coast Guard's new ice breaker design, Fitzgerald and Richards spent five days aboard an existing polar ice breaker, the *Polar Sea*.

spark a fire in this particular space. Once a fire starts, the method asks, what is the probability it will become established? In other words, is there enough fuel—paper, clothing, insulation, and so on—near the source of ignition to sustain a flame?

Should the fire become established, are there automated fire systems—sprinklers, halon extinguishers and so on—in the compartment? Will they be activated? Will they work? Can they extinguish the blaze? If the automated systems fail to control the fire, can fire-fighting teams get there in time and can they bring it under control?

If manual fire fighting can't stop the fire, will the walls and other barriers be able to confine the fire to the compartment where it originated? Will a hot spot on a bulkhead ignite a fire in an adjacent compartment? Will an open door or a pipe passing through a bulkhead enable the fire to spread?

If the fire spreads to another space, the method goes back to the top of the fault tree and begins the process again for the second compartment. As the fire progresses, the method tracks its propagation as it attacks another space, then another barrier, then another space, and so on.

Each step in the fault tree is supported by a fault tree of its own. For example, to determine whether an automated fire suppression system will work when it is activated, it is first necessary to ask whether the system is large enough to handle the fire. If it is large enough, is it charged with an extinguishing agent? If so, has it been properly maintained?

By reducing each step in the development and progression of a shipboard fire (as well as each factor that potentially might stop that fire) to a discrete probability, the method enables an engineer to evaluate how specific changes in the design of a ship, or potential changes in fire-fighting technology and procedures, might affect the ship's overall level of firesafety.

"We can find out, for example, what will happen if we make changes or improvements at any point in the process," Richards says. "If we improve a fire-fighting nozzle or change the material in a barrier, we can see right away what impact it has on the fire scenario. Since we know how much it would cost to make these changes, the method lets us develop cost/benefit analyses."

"The method enables us to make informed decisions," Fitzgerald notes. "It lets us directly compare effectiveness and cost. I have seen cases where expensive improvements were made to buildings without impacting safety at all, and other cases where simply arranging a room a bit differently made a big difference. The method allows you to evaluate changes in advance so you can invest your money where it will have the greatest impact."

Firesafety Below the Waves

While the focus of much of WPI's marine firesafety research has been on surface ships, one early project looked at fire risks on vessels that travel beneath the waves. In 1985 the Electric Boat division of General Dynamics Corp. turned to researchers at the Institute for help in developing a model that could predict the outcomes of submarine fires.

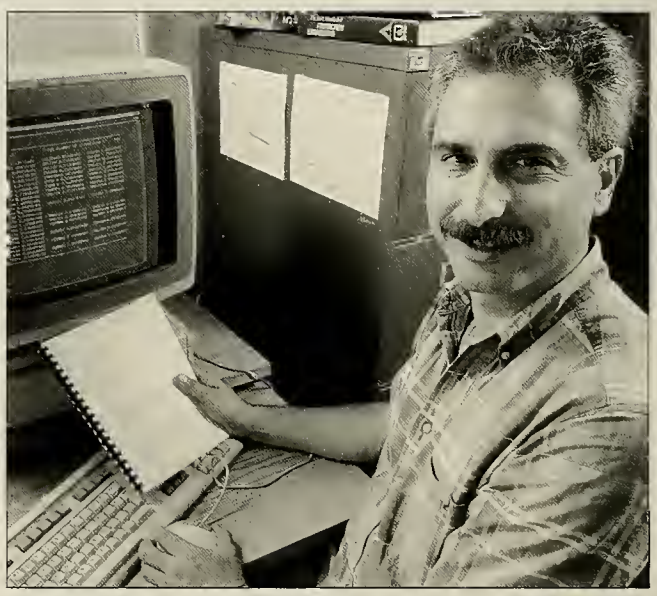
Over the next three years, Jonathan R. Barnett, assistant professor of fire protection engineering, modified a computer model he had developed for studying fires in buildings so it could be used in submarine design.

The required changes, Barnett says, included the need to address the fact that submarines are constructed of different materials from those found in most buildings. For example, the bulkheads—the nautical term for walls—are often built of steel or aluminum.

Because of the difficulty of evacuating a submarine, the model also had to consider the need for sub crews to detect and extinguish fires much more readily than the occupants of most buildings need to.

In addition, the model had to simulate the hot spots that develop in the ceiling over a fire, something that generally receives little attention in building firesafety design. In a submarine, the ceilings—or overheads—often carry critical communication, computer and power wires. Hot spots that destroy these wires could seriously impair the ability of a submarine to perform its mission, Barnett notes.

One of the aims of Barnett's work was the development of a fire model that could be used by submarine designers. "There are quite sophisticated models that can provide the answers these designers need," Barnett says, "but they can take a day or two to complete one simulation, eating up a lot of computer power in the process. We had to think about which aspects of the model were important and which could be discarded to arrive at a model that could be run in real time."



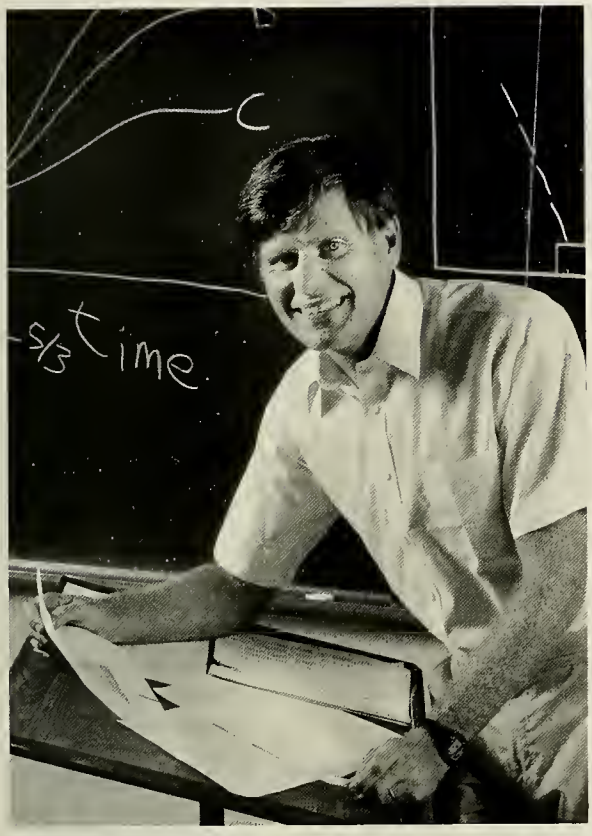
JANET WOODCOCK

A computer model developed by Jonathan Barnett tackles the special challenges of firesafety in submarines.

To make the model as useful to the designers as possible, Barnett created help screens and put together user guides that included sample problems pertaining to submarine design. "Creating a fire model for a specific type of design engineer was something that had never been done before," Barnett says.

The first major opportunity to test SFSEM came when the Coast Guard decided to design a new generation of polar ice breaker. The Coast Guard's most rugged class of cutter, the polar ice breaker is designed to protect its crew from extreme cold as it keeps some of the world's northernmost and southernmost shipping lanes free of ice.

Before the firesafety evaluation could begin, an extensive database was constructed—based on a preliminary design for the new ship—containing information about the ship's layout, the composition and thickness of its bulkheads and decks, the fuel load in each of its compartments, and the location and type of all of its fire-fighting equipment



JANET WOODCOCK

An expert in fluid mechanics, Brian Savilonis is developing a model that will track the complex movement of smoke through a ship.

—automated and manual. To gather some of this data, Richards and Fitzgerald spent five days aboard the *Polar Sea*, an existing Coast Guard polar ice breaker. While on board they studied normal operating procedures, catalogued the contents of typical compartments and observed a fire drill.

To determine the probability that any one compartment in the proposed ice breaker would be impacted by fire, the engineers started a simulated fire in every other compartment and watched to see if it would reach the target compartment. This technique was performed over and over again, each time with a new compartment serving as the target. In all, well over 160,000 simulations were required to complete the analysis.

"After we ran the simulations, we could see that certain compartments had a relatively high susceptibility to fire," Richards says. "We were then able to look for the weak links in the chain and fix them."

As part of the analysis, Richards says it was necessary to think about how a fire aboard the ship might affect its primary missions, which include ice breaking, scientific research, cargo transportation and search and rescue duty. In the process, Richards and Fitzgerald realized that a better method was needed to undertake this type of analysis. For his master's thesis, Hamid Bahadori developed a technique in which ship designers first determine the ship's most critical missions, then determine which equipment is required to carry out those missions, and finally, identify the compartments that contain the equipment. The method will help pinpoint compartments that require special attention in future firesafety analyses.

One of the most important "missions" of the polar ice breaker is sustaining the lives of its crew in the extreme cold of its normal operating environment, a task that requires the continuous operation of the ship's boilers. Should a fire knock out all four of the boilers, the result would almost certainly be catastrophic.

"Because the designers recognized that the boilers are a high priority, they built redundancy into the preliminary design," Richards notes. "But if they had placed all four boilers in the same compartment, they would have made them all vulnerable to damage from a single fire. Based on our recommendation, the boilers will be placed in two compartments separated by a steel bulkhead when the ship is eventually constructed (the Coast Guard is awaiting funding from Congress). The method gave us the rigor to identify problems like this and evaluate alternative solutions."

To arrive at the probabilities it uses to perform its fault-tree analyses, SFSEM makes use of scientific data—formalized into deterministic equations—whenever possible. For areas of firesafety that are not yet supported by scientific data, the method uses engineering judgment—essentially rigorous, highly informed estimates. More study will be required before deterministic equations can be worked out for these areas, Fitzgerald notes. Richards says he would like to see every element of the method ultimately supported by such equations. Toward that end, work is now under way at WPI on plugging two important gaps—the behavior of smoke in a ship and the performance characteristics of barriers.

To provide the needed data on barriers, Jonathan R. Barnett, assistant professor of fire protection engineering, is adapting work he previously completed for the American Iron and Steel Institute on fires in steel-framed buildings. For the institute, Barnett worked on new analytical techniques that determine whether the steel building frameworks provide adequate protection against fire.

"We found that many steel structures are overdesigned," Barnett said. "Some of the money that is often put into making the steel framework stronger, could be put somewhere else—into sprinklers, for example, which protect not only the building, but the people in the building." In work that is just now getting under way, Barnett will use these techniques to study the performance characteristics of steel barriers on ships.

The simulation of smoke movement has traditionally been the weakest aspect of many fire models, according to Brian J. Savilonis, associate professor of mechanical engineering. In work sponsored by the U.S. Coast Guard, Savilonis, an expert in fluid mechanics, is tackling this important area.

There are two primary hazards associated with smoke, Savilonis says. Because it often consists largely of toxic and noxious gases, smoke can impair or kill passengers or crew members. It can also form an opaque barrier that makes it difficult to locate exits and hinders attempts by damage control teams to find and extinguish fires.

Attempts to model the way in which smoke travels through a ship, or to predict the rate and direction of smoke movement, are often confounded by the fact that ventilation systems can quickly transport smoke from space to space.

"It is not unusual for a fire to smolder or burn undetected for 15 minutes—even half an hour. During that time smoke is being produced and moving into the HVAC system. It may show up far removed from where it is being generated," Savilonis says. "You might have a fire on the first deck and detect smoke on the fourth deck. A fire in the aft of a ship might cause fatalities in the forward part of the vessel."

Tracking this complicated phenomenon is difficult because the movement of any type of fluid—including smoke—is nonlinear. "You have to look at all of the areas to which the smoke can travel simultaneously, because they are all physically interconnected."

The model Savilonis is developing will eventually be able to determine, given the various paths that smoke can take in a ship—doors, hatches, ducts and so on, the probability that smoke from a fire will reach a critical concentration at any particular point.

A long-term goal, he says, is to be able to look at the plans for the ship's ventilation system and determine how that design should be changed to best protect inhabit-

U.S. COAST GUARD PHOTO

Currently, the engineering framework is being used to evaluate fire fighting protocols for small Coast Guard cutters.

ants from the hazards of smoke. "It should enable a designer to make decisions on the basis of cost effectiveness," he notes.

He says the model should also be useful for evaluating the effectiveness of fire-fighting procedures. "It will show the impact of various actions," he says. "You'll be able to see how closing or opening dampers in the HVAC system, or how turning fans on or off, will affect the movement of smoke."

In the same way, the model could assist in forensic investigations of ship fires, showing how actual pre-fire conditions and fire combat activities influenced the progression of the fire and how changes in the design of the ship itself might have changed the outcome.

Forensic work is also a natural application of the method Fitzgerald and Richards have developed. "It gives one the unique opportunity to look at a ship in a fire-free state, and then reconstruct the fire, evaluating the effectiveness of such aspects as the manual fire fighting, the detection systems, and so on. Because it looks at the whole system, the method can provide a lot of information fire researchers might not otherwise be able to gather."

Currently, Richards says the Coast Guard is working with WPI on a new project, developing and evaluating a new fire-fighting protocol—a doctrine that covers everything from how fire fighters do their job to the types and locations of automatic detection and suppression systems—for the service's smaller cutters. Currently all Coast Guard cutters employ a doctrine designed for the larger ships in the Coast Guard fleet.

"We started thinking, 'how are we going to determine if a new doctrine is better that the old?'" Richards says. "We'll use the engineering method to evaluate what we do now, and then come up with suggestions for improvements and run them through. With projects like this, we're seeing how the method can become a powerful tool for analysis and comparison."

A longer range goal, Richards says, is to use the framework and other fire models to support the development of marine firesafety regulations. The Coast Guard's Marine Fire and Safety Research Division reports to two of the service's headquarters units in Washington, D.C., Richards notes. One is an engineering unit responsible for the design of Coast Guard cutters. The other, the Office of Marine Safety, Security and Environmental Protection, is responsible for promulgating regulations for U.S. commercial vessels and for working with the International Maritime Organization to improve marine safety regulations worldwide.

The potential impact of computer models on marine fire regulations was the subject of research completed by the first Coast Guard officer to earn a master's degree in fire protection engineering at WPI through the U.S. Coast Guard's post-graduate program. Lt. Stephen J. Ohnstad, who now works on regulatory matters at Coast Guard headquarters in Washington, looked at how the application of a widely used fire model, called Hazard I, might help in the development, interpretation and enforcement of regulations.

Currently, Coast Guard Lt. Roy A. Nash is working on a master's thesis that addresses another area of concern for Coast Guard and International Maritime Organization regulators—firesafety aboard international passenger ships. In particular, Nash is researching the factors that impact the safe egress of passengers and crew in the event of a fire.

Looking back through investigations of past passenger ship fires, Nash says he is finding common failures in the response of personnel, and in the performance of what he calls the "fire protection system," which covers every action or inaction that takes place from the moment a fire is detected until occupants have reached safe refuge.

Nash says his thesis will attempt to identify the shortcomings of fire protection measures currently permitted by regulations, and propose alternatives for limiting the exposure of occupants to fire and smoke along escape routes. "The idea here," he says, "is to put the goal of safe egress on a par with the goal of fire extinguishment."

The work of Nash and the other researchers at WPI and the Coast Guard may take on increasing urgency in the years ahead as a new generation of passenger liners that will dwarf existing ships begin cruising the seas. On the drawing boards are ships the size of small cities and floating islands complete with hotels, lagoons—even palm trees. "The fire in the MGM Grand Hotel in Las Vegas a few years ago, which killed 87 people, was a real headline grabber," notes David Lucht. "A fire on one of these super cruise ships could be much worse."

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Now on the drawing boards, a new generation of super ocean liners—some capable of carrying thousands of passengers—will provide a challenge for firesafety engineers.

RIDING THE RAYS

By Ruth Trask

WPI's Starduster puts in an award-winning performance in the 11-day, 1,650-mile GM Sunrayce USA.

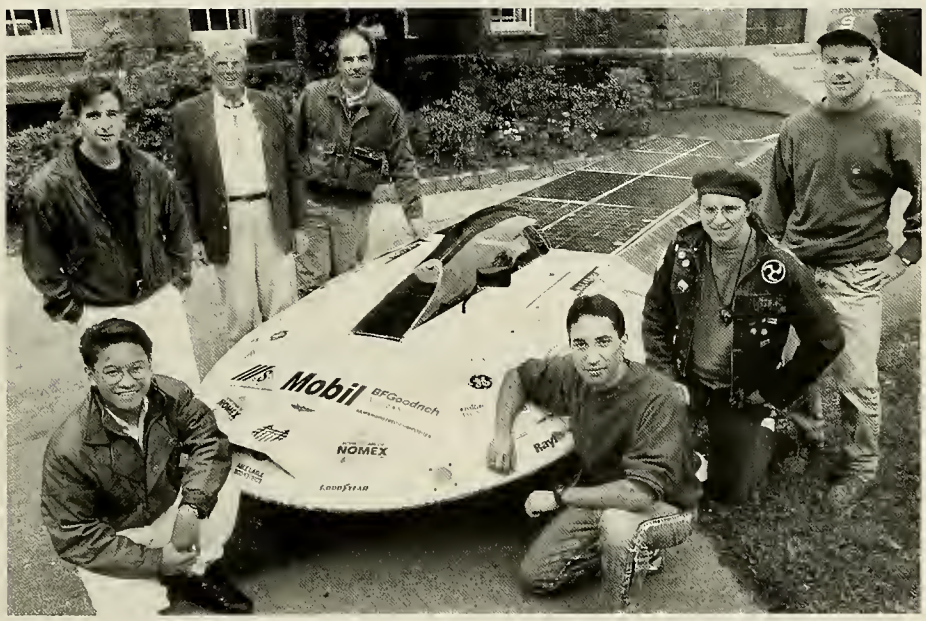
The members of the WPI solar racing team woke to a gloomy sight on July 13, 1990. Dark clouds hovered over the town of Haleyville, Ala., where they had spent the night, and the rains of the past few days had turned much of the solar car staging area to mud.

It looked like Day 5 of the 11-day GM Sunrayce USA, a 1,650-mile race from Epcot Center in Orlando, Fla., to the General Motors Technical Center in Warren, Mich., would bring more of the gray skies, rain and thunderstorms that had greeted the WPI team and competitors from 31 other U.S. colleges and universities for much of the contest. To top it off, it was Friday—Friday the 13th.

Despite the foreboding start, Day 5 turned out to be a lucky one for WPI. Following a bold strategy, the WPI team ran its car, named Starduster, full-out on battery power. Having worked its way to the front of the pack, the car broke free of the heaviest clouds and managed to catch three hours of partial sun before the day was out. The plan enabled Starduster to complete the 140-mile hilly run from Haleyville to Spring Hill, Tenn., in just under seven hours, leaving the rest of the competition in the dust.

"On the 13th we passed the leading contenders, trouncing Western Washington by 90 minutes and the University of Michigan by two hours," says Edward N. Clarke, director of WPI's Center for Solar Electrification and one of two Starduster faculty advisors. "Competitors began calling Starduster the 'Worcester Rocket.'"

That night the team was congratulated at a formal awards ceremony by Robert C. Stempel '55, then president of General Motors, who would, in just a few week's time, assume the chairmanship of the world's largest manufacturing enterprise. In a ceremony at GM's Saturn plant in Spring Hill, Stempel presented the students with the prized orange T- shirts, awarded each evening to the team that won the day's leg.



JANET WOODCOCK

With Starduster are (clockwise from far right) Daniel G. Murphy '91 (member of a new Starduster project team), Alan Allen '91, Avi Klinger '90, Armand Aquino '91, David Scampoli '91, and faculty advisors Edward Clarke and Roy Richard.

The win on Day 5 was just one of many successes chalked up by Starduster, a sleek, solar-powered racing vehicle entirely designed and constructed by WPI students. (On other days the car finished 4th, 7th and 8th.) On the last day of the race the WPI car passed 22 other competitors to cross the line in 4th place for the day and 14th place overall. For its performance in the Sunrayce, it was named the second most improved car in the competition.

Starduster was the work of 25 WPI students who labored over the course of a year to design and build it (see related story). The value of the finished car is about $50,000, according to Clarke. Including travel expenses, the cost of a trailer to carry it to and from the race, and the value of support facilities, the final price tag for the WPI entry was less than $100,000. Several competitors spent considerably more on their cars—the winning vehicle, built by students at the University of Michigan, cost about $800,000.

According to Clarke, the generosity of several corporations and institutions made possible the construction of Starduster. Mobil Solar Energy Corp., for example, donated the solar cells and let students

Edward Clarke points to the standings board on Day 5, when WPI led the field by well over an hour.

Professor Roy Richard (left) and Avi Klinger tend to some tire problems during pre-race trials at Daytona Speedway in Florida.

put together the solar modules at the company's plant in Billerica, Mass. BST Systems in Plainfield, Conn., which manufactures silver zinc batteries for the U.S. Navy, provided Starduster with what team members said was the best battery in the Sunrayce—a model custom-made for Starduster.

A&M Composites in Marlboro, Mass., a subsidiary of B.F. Goodrich that makes composite parts for submarines and airplanes, made space available in its factory and walk-in ovens to the WPI team. It was there that Starduster's composite body was manufactured. Help was also received from Robert K. Butler, a 1964 graduate of WPI's Master of Natural Science program, who recently retired as superintendent of the Worcester Vocational School Department. Butler provided valuable work space in a large vocational school building not far from the WPI campus. The Alden Research Laboratory in Holden, Mass., not only made space available for the solar car project, it is keeping space free for future projects, Clarke says.

In addition to these "in-kind" donations, the solar car project received financial support from a number of sources. General Electric donated $5,000. Raytheon, through the efforts of James G. Hackendorf '60, also contributed $5,000. Individual alumni and friends gave a total of about $6,000, some of which was raised in a unique "Adopt A Solar Cell" campaign. As did all teams entered in the Sunrayce, WPI received $5,000 from General Motors and $2,000 from the U.S. Department of Energy—primary sponsors of the race along with the American Society of Automotive Engineers. Six undergraduates accompanied the car on its run from Florida to Michigan: drivers Avi T. Klinger '90, captain of the WPI solar car team, Joseph P. Auger '90, Armand A. Aquino '91, and Andrew J. Stern '91; Mark N. Forget '90, the chief driver of the chase van that accompanied Starduster during the race; and Alan C. Allen '91, who captured the Starduster story on videotape (see accompanying story) and helped out as a team member during the race. Of these, three—Allen, Klinger and Stern—watched Starduster go from idea to design to finished vehicle. Graduate student Mark A. Hampson, who helped guide the project from its inception, was also a member of the race team.

Aquino was a last minute addition to the Starduster team. "I was already finished with my IQP in support of Starduster, but decided I wanted to work on the car anyway," he says. "My strong points are suspension and connections. In my spare time I race sophisticated model cars. I had hoped to contribute some of my experience to the project."

On a project as complicated and innovative as the construction of a new solar vehicle, it's natural for differences of opinion to arise among the designers about details of design, construction and operation. According to Aquino, the Starduster project had its share of disagreements.

"We didn't always agree on everything while Starduster was being constructed," he reports, "and later we often didn't see eye to eye on how the car should be raced. One thing we all agreed on, though, was that we'd go through everything again just to get behind the wheel in a solar race. The last six days were fantastic."

On one of those last six days the WPI team picked up an unexpected award, notes Roy V. Richard II, assistant professor of mechanical engineering at WPI, and the chief engineering project advisor and race strategist. "Officials from the Swiss Tour de Sol, an annual race of solar vehicles in Europe, presented a surprise award to the WPI car for having the best hill climbing capability," Richard says. "Starduster bested its nearest competitor by nearly a minute during the steepest portion of the race at Madison, Ind."

"We told Armand Aquino, the driver on that stretch, to floor it," Clarke says. "Actually he took the hill so fast that sometimes our lead van could hardly stay ahead of him."

The award was presented at a special ceremony held at the Indianapolis Speed-

Starduster's award-winning hill climb.

Anatomy of a Hill Climber

Starduster's exceptional ability to climb steep hills powered only by electricity from the sun, owes much to its battery and unique, aerodynamic design. That design was largely the creation of 25 students whose work on the solar car constituted their Major Qualifying Projects, one of three projects required of all undergraduates under the innovative WPI Plan.

Advised by Roy V. Richard II, assistant professor of mechanical engineering, and Edward N. Clarke, director of the Center for Solar Electrification, and ably assisted by graduate students Mark Hampson (mechanical engineering) and Thomas Murphy (electrical engineering), the students worked in groups to fashion the car's aerodynamic profile, structural components, solar array, motor and motor controller, battery, cooling system, transmission, front suspension, rear suspension, steering system, wheels and brakes, and driver systems.

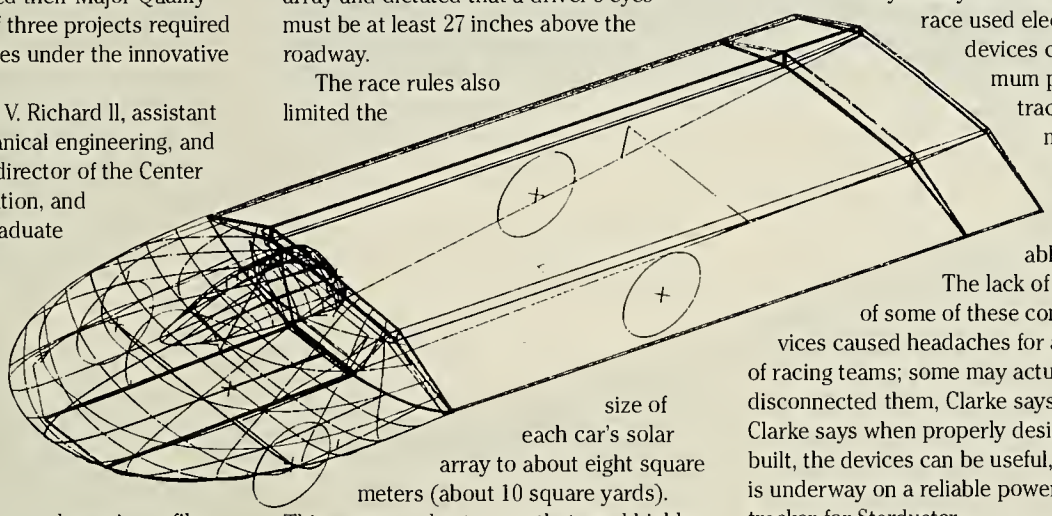
A critical design review committee, consisting of representatives from the manufacturers that supplied materials and equipment for the car, other technical experts, and members of the WPI faculty, met several times during the year to give students advice and guidance during the design process.

Starduster's most visible component is its semimonocoque body—a sturdy shell that requires no supporting metal framework. Made from Kevlar and graphite layered on a core of Nomex honeycomb, the structure is surprisingly lightweight. Without a driver, the finished car weighs just 500 pounds (including a 110-pound battery).

Using computer-aided design and simulation techniques, the students gave the body a low, streamlined profile to enable it to cut through the air with little drag. Scale models of the design were tested in a wind tunnel to further evaluate Starduster's aerodynamic profile.

The car's dimensions—19 feet long, 6.5 feet wide and 3 feet high—were largely determined by the Sunrayce rules, which placed upper limits on the size of the solar array and dictated that a driver's eyes must be at least 27 inches above the roadway.

The race rules also limited the size of each car's solar array to about eight square meters (about 10 square yards). This gave an edge to cars that used highly efficient—and also highly expensive—cells designed for powering satellites, Clarke says. WPI's car, like many of the Sunrayce entries, used less expensive cells made for use in commercial and residential solar arrays. Designed to generate 800 watts in peak sunlight, Starduster's 16 solar modules produced 700 watts on a typical, sunny day, and much less on a cloudy day.



Surprisingly, the student designers opted to use fewer solar modules than the race rules allowed. While running simulations, the aerodynamics and solar array groups realized that by removing one of three rows of modules planned for the top of the car, the profile of the car—and the resulting drag—could be reduced enough to more than compensate for the loss of energy.

Translating the energy from the solar cells and the car's custom-made silver zinc battery into forward motion was a 10-horsepower brushless DC motor made by Unique Mobility of Colorado. This $8,000 device (including the cost of the controller), which Clarke says was the best power plant in the Sunrayce, also powered about 12 other entries.

While advanced design and technology contributed to Starduster's stellar performance during the race, the car may also have benefited from one piece of technology it did not employ, Clarke notes. He says many of the cars in the race used electronic devices called maximum power point trackers to make the best possible use of available sunlight. The lack of reliability of some of these complex devices caused headaches for a number of racing teams; some may actually have disconnected them, Clarke says. Still, Clarke says when properly designed and built, the devices can be useful, and work is underway on a reliable power point tracker for Starduster.

While Starduster's electronics worked well, the car did have its own Achilles' heel. To save weight, elements of the car's steering system had been made from aluminum. Under the strain of actual use, the aluminum parts began to twist, making the steering less precise. After the race was under way, the Starduster team replaced the failed elements with steel parts and no further problems were encountered during the race.

The combination of technology and design added up to a powerful and efficient solar car, Clarke says. During the race, the car was briefly clocked at 60 mph—the drivers agree that it can probably travel considerably faster.

The car also traveled at a sustained 36 mph using just the energy from its solar cells. The world's record for this mode of travel—about 45 mph—is held by the General Motors Sunraycer, which set the mark with its batteries removed. "Sunraycer cost more than $3 million," Clarke says. "We approached its record in a $50,000 car. That's not bad!"

—Michael Dorsey

Solar vehicles from 32 colleges and universities circle the Indianapolis Speedway, becoming the first cars not competing in the famed 500 to be allowed on the track.

way. It was the first time in history that cars other than those competing in the famed Indy 500 were allowed on the racetrack.

Clarke and Richard say they were especially gratified at how easily Starduster managed the hill climb, since a number of other cars were unable to complete the climb or opted to take an hour penalty and be trailered up. They note that Starduster performed better on hills because of its unique aerodynamic design and power system.

"It had one of the smallest frontal areas in the race," Clarke says. "It also has a powerful battery and motor system and is finetuned for low rolling friction."

Starduster's "military-quality" battery gave the car an important edge over most of the other competitors, who used commercial batteries, Hampson says. "We relied much more on our battery than on our solar cells, which were not as efficient as the expensive space-quality cells used by some of the larger universities. As a matter of fact it was the battery and our efficient motor that enabled us to win the hill climbing competition. If we'd had more efficient solar cells, I'm sure we'd have come in first overall, as well."

Another feature that aided Starduster's performance was its aerodynamic shape. Mark Hampson says the car is so low slung and sleekly designed that even the wind from passing trailer trucks could barely move it an inch. Competitors judged it one of the most stable cars in the race.

Starduster was the second WPI solar car on which Hampson had served as an advisor. The first, completed in 1989 just before the start of the first American Tour de Sol, put in a disappointing performance in the Montpelier, Vt., to Cambridge, Mass., race. "Sometimes I put in nearly 24 hours a day of hands-on work on Starduster," he says. "It is much better designed than the car we developed the year before. We tried to get the bugs out this time."

Hampson says team members road-tested the new vehicle for 150 miles in Worcester prior to entering the solar race. "We put about 20 hours on the motor," he reports. "Some colleges didn't turn on their motors until the first day of the race."

Road-testing not only helped break in Starduster's systems, but gave the drivers a chance to get in some time behind the wheel. Once the Sunrayce was under way, the drivers had to maneuver the solar car down public roads and highways while Hampson, Richard and Clarke rode directly ahead in one van and the remaining team members followed in another.

"In general, we had few traffic problems," says Hampson. "We had no police escort, except in Louisville, Ky., and Warren, Mich." Klinger says he especially remembers a police officer in Louisville who traveled through the city stopping traffic to let the race cars have the right of way. "I was so impressed, I leaned out of the chase van I was driving and handed him a GM Sunrayce hat to show our gratitude," he says.

According to Clarke, there was a slight glitch as the race got started at Epcot Cen-

Documentary Chronicles

A frame from a video documentary on Starduster by students Alan Allen and David Scampoli.

One important member of the WPI Solar Racing Team was neither a driver nor an advisor. Alan Allen '91, working with fellow producer David M. Scampoli '91, made a video documentary that followed the solar car project from start to finish. "I was already making a documentary on photovoltaics at WPI for my Interactive Qualifying Project," he says. "Following the development of the solar car seemed to be a natural thing to do."

A mechanical engineer, Allen says he also turned out to be the "tire person" after Starduster had a couple of blowouts just prior to the Sunrayce. He discovered what the problem was, found a way to fix it, and from then on there were no more tire troubles.

Allen and Scampoli's documentary details how Starduster was conceived, designed and built. Starting with the early design meetings, it follows the car as its many components are constructed and assembled.

The documentary also shows the human side of the Starduster story—the problems that had to be worked through along the

ter. Due to an unmarked juncture in the course, the MIT car took a wrong turn and WPI followed. "A number of cars followed us, and we led the entire solar car parade on to heavily traveled Interstate 4 when MIT hesitated, which came as a shock to some motorists. I was fortunate to find the correct exit to get us all back on course," he says.

Team members got a chuckle out of another glitch that occurred during pre-race testing at Daytona International Speedway. "At that point none of us was too familiar with operating the controls of the car," Aquino says. "Avi Klinger, as captain and a prime builder of the car, was one of our first testers. He started the car and began to race—not forward, but backward."

Hampson reports that the competing cars averaged about 160 miles a day on the road, but occasionally hit 200. Sometimes, during the heavier mileage days, two students split the driving duties. To comply with Sunrayce rules, the drivers had to carry ballast to bring their weight to exactly 174 pounds.

He chuckles. "At one point, however, Aquino found himself with an unexpected passenger when a butterfly was sucked into the canopy."

Andy Stern is interviewed by a reporter from cable network ESPN on Day 5. Looking on are (left to right) Mark Forget, Avi Klinger, Alan Allen and Armand Aquino.

Despite the high daytime temperatures, which occasionally hit 95 degrees, the drivers stayed comfortable inside a canopy coated with a special material designed to reflect most of the heat-producing solar rays. A scoop at the front of the car directed a cooling flow of air over the driver, especially when the vehicle was traveling more than 20 mph, Hampson says. "Usually it cruised at 40 mph and occasionally hit 55."

While most of Starduster's systems performed well throughout the 11-day race, a few snags did crop up early on. Especially vexing were a lingering problem with the front end and trouble with the steering mechanism. The latter difficulty was solved by changing some parts in the steering system.

Laurent O. ("Larry") Rheault '79, one of several WPI alumni who showed up at critical times during the race, was on hand to help out on one particularly troublesome day. Rheault, who drove all the way from Pensacola, Fla., to Montgomery, Ala., was on hand for what became known among team members as "Bad Day 3."

"There we were with a broken trailer axle, Starduster steering problems, and lost hotel reservations," Clarke says. "Larry caught up with us in the middle of the night, willing to help with everything."

Among the other alumni who watched the race and provided support were Thomas K. Caste '61 and his wife, Ann, and their daughter, and Col. Frank R. Lindberg '41 (USAF Ret.) and his daughter and grandson.

The WPI team spent only one night in a hotel during the race. The rest of the time they slept in vans, in tents and in the trailer in specially designated camping areas. In Louisville they camped out at Churchill Downs and heard the horses being exercised in the morning.

The night of July 12, the day before the

The Starduster Story

Allen at work. His documentary shows the human and technical sides of WPI's solar racing efforts.

way, the technical headaches that frayed nerves during the race and the camaraderie that developed among the team members by the time Starduster crossed the finish line. Included are interviews with many of the students and faculty members who made the project a success.

"There are two things that I especially remember about the race: the heat, and the frequent search for a football field with sprinklers or a public pool," Allen says. "Once a lifeguard invited us to use a pool even though it was normally closed to visitors. And I'll never forget Professor Clarke calling us to 'rise and shine' every morning at 5:30."

Recently, Allen and Scampoli learned that their documentary won fifth place in a competition sponsored by the U.S. Department of Energy to select the best videos made about the Sunrayce. "Now everyone wants to see it," Allen says. "Ed Clarke says he may take it around to high schools." He laughs. "Who knows? He may even let me fulfill a dream—to drive Starduster, even if it's just around the parking lot."

—Ruth Trask

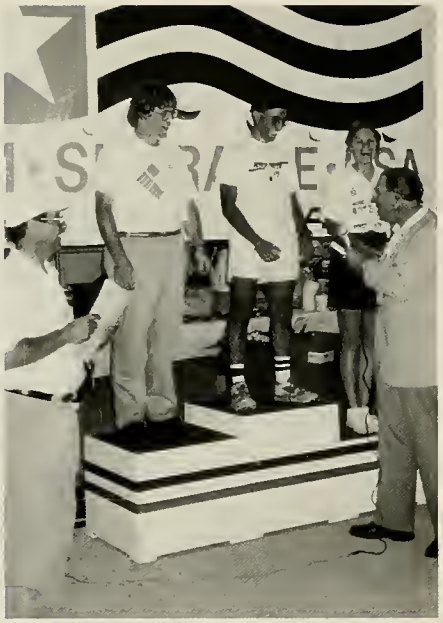
WPI team won the coveted orange shirts, they ate a cold dinner and slept on a hard gym floor in Haleyville, Ala. The next morning minor problems with the car and poor communication among team members fueled testy tempers.

"In spite of such a shaky beginning, we suddenly found ourselves passing nearly all the solar cars on the road," Clarke recalls. "Drivers Avi Klinger and Andy Stern really moved. Lots of people lined the highway, sometimes in large crowds. By the time we reached GM's Saturn plant in Spring Hill we owned first place for the day. Bob Stempel and the WPI team got a lot of attention. It was great!"

On the night before the final day of racing, a big storm swept through the fairground at Mason, Mich., where the team camped. The students say they slept in a dormitory-style building on thin mattresses following a late supper.

On that last day, the WPI team decided to go all out, as they had on Day 5. About a million people watched as the cars neared Detroit. Captain Klinger took chances with the battery, occasionally hitting 55 mph on the 86-mile course.

"When I came to stop signs or red lights, people would run up and ask me all sorts of questions," he says. "They'd ask how fast the car could go and if I were too hot. Most would simply wish me good luck. It was great seeing people of all ages standing on the side of the road waving enthusiastically."

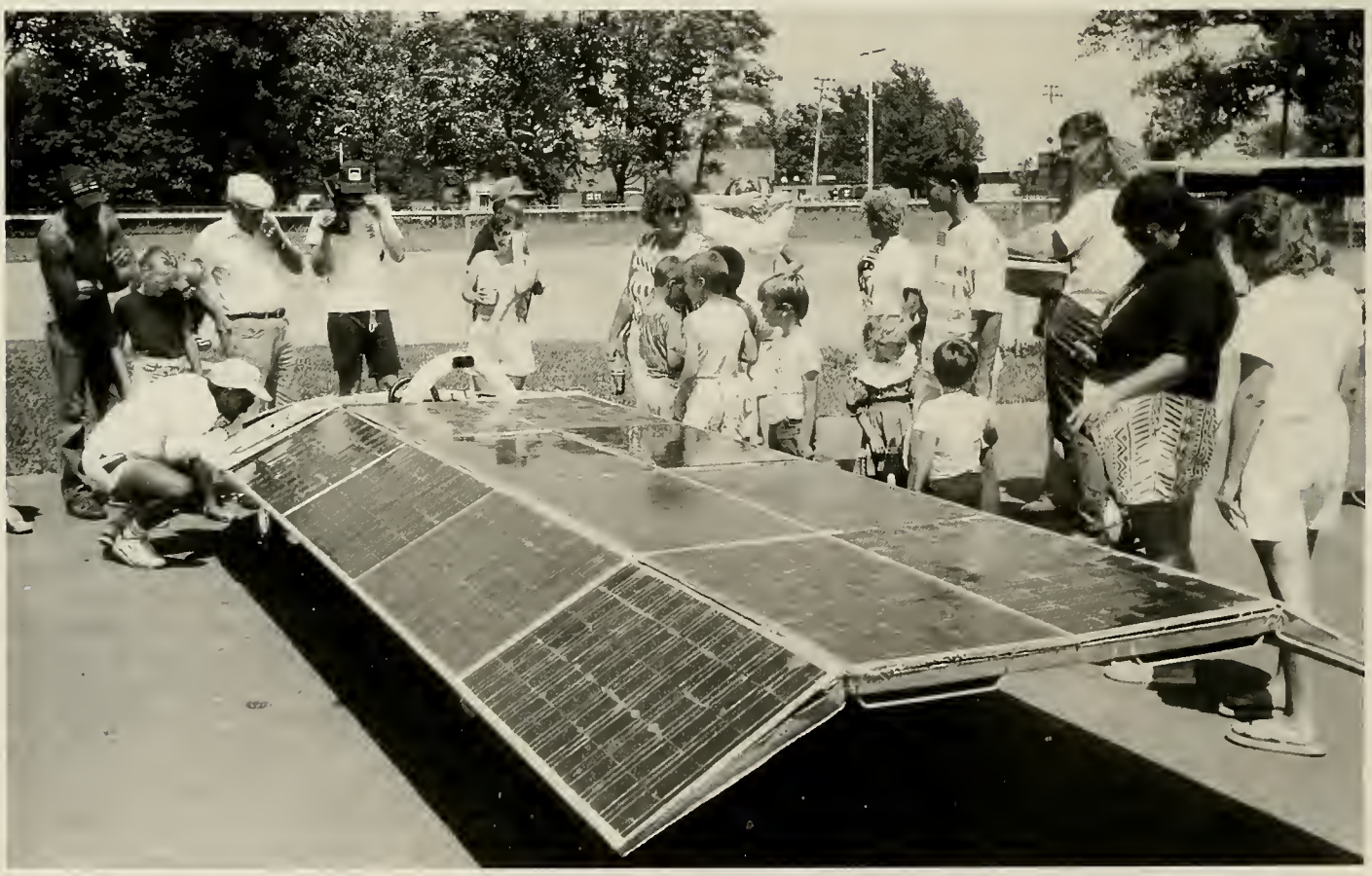


Robert Stempel '55 (far right) congratulates Avi Klinger in ceremonies after the first-place finish on Day 5.

Starting in 27th position, Klinger passed 22 cars during the first 50 miles. As he approached the end of the race, he saw the Goodyear blimp hovering over the leaders, and realized that WPI was right up with the top cars. The last car Klinger passed was the entry from Crowder College. Clarke says the two cars vied for position for several miles, until they arrived at a hill. "We easily overtook them at that point, and ultimately beat Crowder by 16 minutes," he say.

Near the end, a train held Starduster up for nearly five minutes at one point, probably costing WPI a second- or third-place finish that day. Klinger pressed on, though, and brought the car in for a respectable fourth place for the day, only one and a half minutes behind the second- and third-place contenders.

Now that Starduster has fulfilled its mission, will the solar car be retired? "Absolutely not," says Clarke. "A new group of students will design and build some improvements into the car in preparation for its entry in the next American Tour de Sol in May 1991. Professor Richard and I are also thinking about demonstrating its hill climbing prowess with a run up Mt. Washington's auto road."



Starduster and its crew were greeted by enthusiastic and curious crowds all along the 1,650-mile route of the GM Sunrayce USA.

These Few Precious Days

Autumn on a New England college campus is something of a paradox. Fall is the time when nature winds down, bracing for the cold weather and shortened days that lie ahead. But for those who live their lives according to the academic calendar, the season is a time of rebirth.

JANET WODOCOCK

(Previous page) The tower of Washburn Shops, named for WPI founder Ichabod Washburn. (Clockwise from below) The carillon tower of Alden Memorial Auditorium; campus foliage at its peak; the campus from the air (a 40-by-60-inch print of this photograph now hangs in the Gordon Library, a gift of Edward B. Wysocki '59 and his sons, Edward Jr. '81 and Joseph '83); Salisbury Laboratories bedecked in autumn hues. (Next page) The baseball diamond peeks through a stand of pines that borders the gardens of Higgins House.

JON REIS

JANET WOODCOCK

As the last glimmer of summer fades into the first cool days of fall, the corridors of WPI's academic buildings, which have been still and strangely hushed for many weeks, reverberate once again with hurried footsteps and lively conversation. Classrooms and laboratories spring to life, residence halls ring with music and laughter, the library hums with studious activity, and the athletic fields resound with the roars of enthusiastic crowds.

For many, fall is also the loveliest time of year to stroll through the WPI campus. Painted in the glorious shades of the autumn palette, the foliage of trees, shrubs and ivy blend in a subtle harmony with the warm brick of the campus's buildings, and contrast sharply with the season's clear, azure skies. It is a time that encourages long walks and idle musings.

In these four pages we've captured some of the beauty and drama of fall at WPI through the lenses of photographers John Reis and Janet Woodcock.

NORTHEAST AIRFOTO SERVICE

JANET WOODCOCK

Timeline

A Journey Through WPI's First 125 Years

By Neil Norum

November 1868: The Experiment Begins

EDITOR'S NOTE: *In the last three installments of this series we have taken readers back to the late 1950s, the 1920s and the late 1890s to catch a glimpse of WPI and the world through these three windows in time. In this, our final stop, we arrive at November 1868, the year WPI—then known as the Worcester County Free Institute of Industrial Science—opened its doors.*

In 1865, the year WPI received its charter, the Civil War came to an end. Four years of bloody strife had left the nation utterly changed and set the stage for a painful period of reconstruction. Three years later the national debt stood at $2.5 billion, down nearly $1 billion since the end of the war. The National Grange, founded in 1867, was helping farmers across the country recover from the ravages of the war. And the Ku Klux Klan, started as the war ended, was becoming active in the South.

The end of the Civil War also opened the door to a period of bold expansion in the United States, a time that would see this now truly unified nation stretch its boundaries increasingly toward the West. The process was not without conflict. In 1868 George Custer's 7th Cavalry was fighting American Indians and a two-year war ended with the U.S. ceding part of northern Wyoming and a parcel of land in the Dakotas to the Sioux. Some would say the nation's expansion had gone too far when Secretary of State William Henry Seward purchased Alaska for $7 million.

As the nation grew, communications between its extremes became difficult. Wells Fargo announced in 1868 that it would begin carrying mail from the East Coast to California—a 2,700-mile run that would take 25 days by stagecoach. Other innovations of that year included the typewriter and an electric vote recording machine invented by young Thomas A. Edison. The railroad industry introduced air brakes, shock-absorbing springs and the first dining car.

The Worcester of 1868 was a bustling industrial and commercial center. The photos on this page are from the collection of the Worcester Historical Museum.

The telegraph station, which connected Worcester to a growing nation.

The talk at social gatherings in 1868 probably turned to the impeachment of President Andrew Johnson and the election of Ulysses S. Grant, and to the growing suffragist movement, which now had its own weekly journal—*The Revolution.* Americans were reading Louisa May Alcott's *Little Women*; some might also have noticed the work of a young author and humorist who went by the pen name Mark Twain.

While there were no supermarket tabloids in 1868, readers were treated to the sensational side of the news by *Leslie's Illustrated.* A headline in the October issue touted "Telegraphy for the Millions," a reference to the transatlantic telegraph cables that had just been laid between New York and France. The weekly covered an earthquake in Peru that unearthed 500 mummies from a graveyard.

Readers of *The Boston Daily Journal* that November saw an ad for the first mortgage

The campus, photographed sometime after the college opened in 1868. On the hilltop are Boynton Hall (left) and the Washburn Shops. In the foreground is "faculty row," the part of Boynton Street where many of the original faculty members lived.

bonds of the Union Pacific Railroad Company, which had already laid 900 miles of track. The following year the famous golden spike would be driven at Promontory Point, Utah, making it possible for travelers to cross the nation in just eight days. Under the headline "Our National Game," readers of that newspaper learned that at the annual meeting of the New England Association of the National Baseball Players in Lowell, the Excelsiors of Worcester had been granted membership.

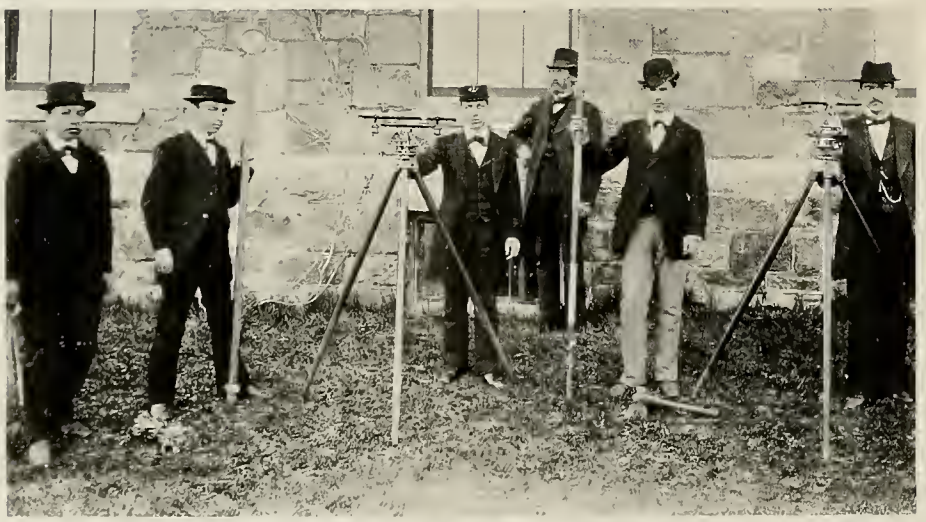
In Worcester, residents frequently turned to *The Worcester Daily Spy* for their news. The Nov. 12 edition noted that the Temperance Organization of Worcester would soon hold a festival in Mechanics Hall. In the competing *Worcester Palladium* that day, readers learned of the unpopularity of England's Queen Victoria, who had recently dissolved Parliament and set the stage for the first general elections to take place under a new reform bill.

By 1868, Worcester had become a city of 40,000. It was served by seven railroads and one of the earliest horse-drawn street railway lines. Gaslights illuminated the streets. Downtown included a central telegraph office, three hotels and an abundant number of banks and churches—but no hospital. A branch of the YMCA had been organized in 1864 and there were a number of organizations devoted to civic welfare and temperance.

The city was also riding the wave of industrial growth that had been spurred by the end of the Civil War. As historian Mildred McClary Tymeson put it in *Worcester Bankbook*, "The old industries of making woolens, leather, munitions and farm machinery increased markedly. The discovery of metals and oil introduced entirely new areas for manufacturing. Transportation gave a liberal dose of adrenaline to the iron and steel industry. Then the use of electricity came along, transferring all labor into terms of speed and power. America was growing. With a big hand pushing out toward the West, it provided new markets almost as fast as it developed new products."

Around the city, older sawmills and gristmills stood side by side with brand new factories turning out textiles and textile-making machinery. The I. Washburn & Moen works led the country in the production of wire, especially music wire and crinoline wire. The emerging machine tool industry was manufacturing plows, cultivators, harrows and rakes. Other factories produced paper-making machinery, carriages, organs, melodeons, boots and shoes. Wheelock engines and boilers, Winslow skates, Torrey razors, and firearms made by Wesson and Allen were becoming known throughout the country.

"It was altogether fitting that such a center should be the seat of an industrial school," noted WPI historian Herbert Taylor in *Seventy Years of the Worcester Polytechnic*



Civil Engineering was part of the Institute's original curriculum. Students learned the techniques of surveying under the tutelage of Aldus Chapin (seen in the background).

The view from the top of Boynton Hill. Jo Bill Road (now Institute Road) traverses the center of the photo. Beyond that, to the right, is Highland Street, which intersects with Lincoln Square near the steeple in the center of the frame.

Institute. "Not only did it provide at close hand a great laboratory for student inspection, but within the walls of these factories there would undoubtedly develop opportunities for the employment of graduates."

Already, New England had seen several notable experiments in science education. Joseph E. Sheffield endowed the Sheffield Scientific School of Yale in 1847. Abbott Lawrence founded the Lawrence Scientific School at Cambridge in 1848. And Abiel Chandler endowed a separate department of technology at Dartmouth in 1852. But as Charles Washburn would later explain in his book *Industrial Worcester*, "These schools all taught pure science. It was left for the Polytechnic School, as later developed, to teach applied science."

In Worcester Ichabod Washburn, founder of I. Washburn and Moen and one of the city's most respected industrialists, had eight years earlier discussed with Seth Sweetser, a prominent clergyman, the feasibility of establishing a school linked to the city's Mechanics Association. The school would provide instruction in physics and chemistry to the city's young mechanics. The financial crisis of 1857 kept the plan from reaching fruition.

While Washburn's idea never took hold, the simple dream of tin manufacturer John Boynton captured the imagination of the city. That dream had taken shape on a hilltop in Worcester's west side, where the towers of the first two buildings of a brand new college now stood like beacons for a bold experiment in higher education. One building, named for Boynton, would provide

Edward K. Hill, Class of 1871.

space for classroom instruction. The other, donated by Washburn and bearing his name, would be a working shop where students would apply their newfound knowledge to practical problems. As November 1868 began, the two buildings stood ready to accept their first students and the Worcester County Free Institute of Industrial Science was standing by to officially open its doors to a curious city.

Beginning in September, advertisements ran in Worcester newspapers announcing that the new institute's first term would commence on Tuesday, Nov. 10. Students wishing to apply for admission, the ads noted, would be required to take an examination on Nov. 5. "Candidates will be expected to give satisfactory evidence of their acquaintance with the usual studies presented in the District Schools of the County of Worcester, especially Arithmetic, Geography and the History of the United States," prospective applicants were advised.

Residents of Worcester County would not be charged tuition to attend the new school, while those living outside the county would pay $60 per year. Accounts vary as to how many students enrolled with the first class. One report put the figure at 32 boys; *The Evening Gazette* in Worcester said there were 27 students in the elementary class and 23 in the junior class, for a total of 50.

The college's first faculty consisted of Charles O. Thompson, who was principal of the new institute and also professor of chemistry; George F. Gladwin, part-time professor of drawing; George I. Alden, professor of mechanical engineering; and Harriet Goodrich, teacher of elementary math and also Thompson's sister-in-law. The modern language and physics positions were unfilled as the school year began.

The date for the official opening of the Institute was set for Nov. 11. According to a newspaper report, the day was unpleasant and the streets were filled with mud. Despite the inclement weather, representatives of nearly all the leading New England colleges and seminaries attended the ceremonies, along with the leading citizens of Worcester County. They assembled at 10 a.m. in the third floor chapel of Boynton Hall for the inauguration of Principal Thompson (then

Edward F. Tolman, Class of 1871.

only 31 years old) and the dedication of the college's first building. They heard from a long parade of speakers who were interrupted only by a one-hour break for a luncheon prepared by local women. The dedication lasted until late in the afternoon.

In *Two Towers*, WPI's centennial history, Mildred Tymeson said the speakers each tried "manfully to put into words the purpose of the school and his hopes for it." One speaker reminded the audience that they were living in an age when people were judged by the kind of speech they could make. On this historic day, said Tymeson, many persons were willing to submit to the test. Among the speakers was D. Waldo Lincoln, chairman of the building committee for Boynton Hall, who spoke about the process of raising funds for and building the college's classroom building.

"We surrender to you...," he said, "a tasteful and substantial edifice, alike credible to him who has designed, and to those who have executed it, and which will go far to remove the reproach which has sometimes been cast upon the city, for the ordinary character of its public buildings. For its commanding and admirable location, for the beauty of its architectural design, for the general excellence of its workmanship and finish, for its adaptation to the uses for which it is designed, and for the economy of its construction, we believe it will rank among the model public buildings of the commonwealth."

Lincoln noted that the total cost of the building came to $75,343.68, which exceeded the total in the building account by $3,924.33. Lincoln touched briefly on the new building's dimensions—146 feet long and 61 feet wide, with a tower 85 feet high—but stopped short of providing a full description of the structure, since "it had recently been given in the public papers."

A full rundown on the building appeared in *The Boston Daily Journal*, which described each room in detail. "On the first floor we find a pleasant, cozy room for the president, the dimensions of which are 15 by 20 feet." The janitor's room, also on the first floor, measured 14 by 23 feet, the paper observed.

Stephen Salisbury, founder and president of the Board of Trustees, added his own expressions of gratitude and commendation and asked the speakers who would follow to answer this question: "What is the need of establishing this school, and how can its object be best accomplished?" Salisbury also noted that two key benefactors of the Institute were not present that day: John Boynton, who had died the previous March, and Ichabod Washburn, who was ill.

Among the speakers who followed Salisbury were Chester S. Lyman of the Sheffield Scientific School and John H. Woodman of the Chandler Scientific School of Dartmouth. Lyman described the three ingredients necessary for the survival of a good college—money, wisdom and good teachers. "It is difficult to say which is the most important," he said. "Neither one is effectual without the others....Wisdom is more difficult to find than money....The living force of the college is the teacher, and the power of the institution rests in the hands of each instructor.

"You are too modest in your hopes of this new institution," he added. "It will, indeed, fit young men better for the practical work of the various industrial pursuits of the region, and more than that....Let this be the model institution of the region. Let its plan, methods, aims and spirit pervade and elevate the whole educational system around you. Let its culture, directly and indirectly, in due time, ennoble every person in this region."

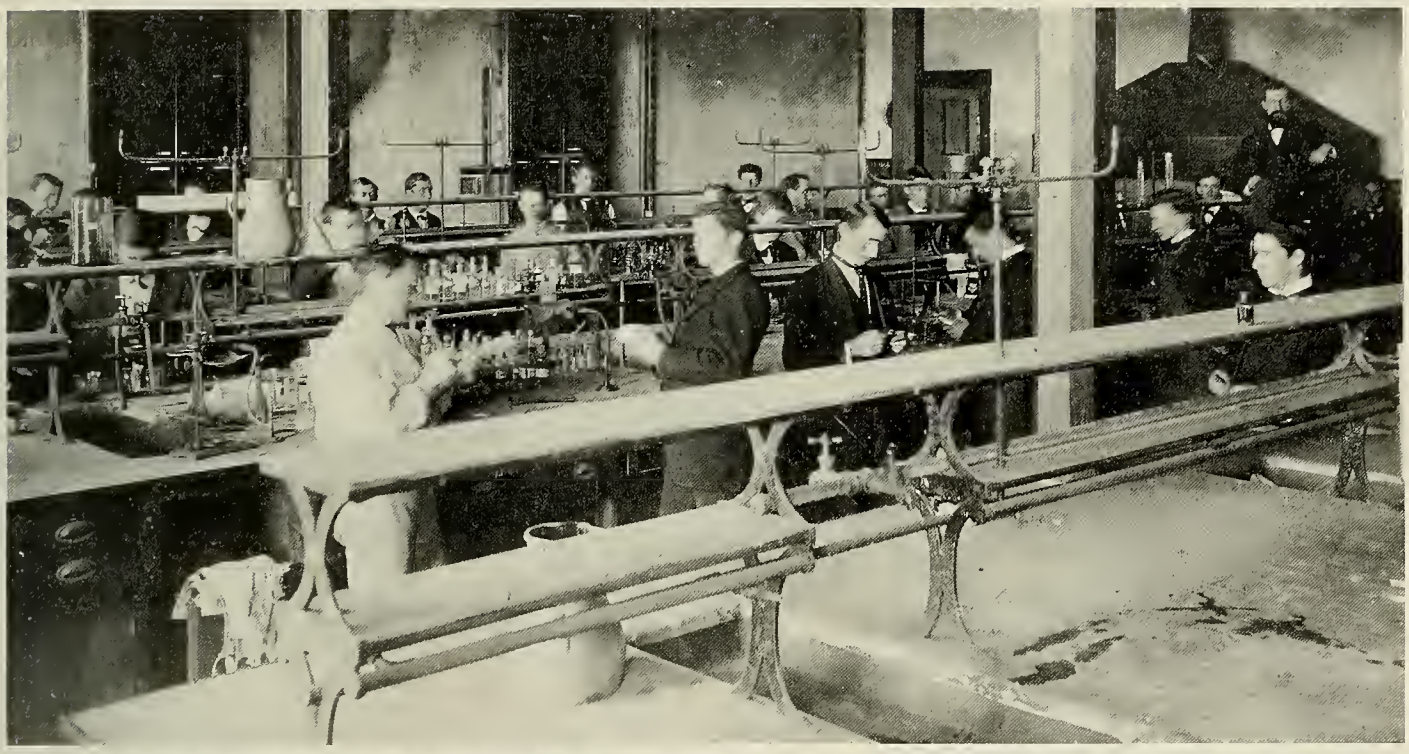
Charles Thompson spoke in "clear and simple language of the developments in education," Taylor noted. He traced the history of the school's creation, outlined the scope of the educational plan, and touched upon the observations he had accumulated visiting and observing the technical schools of Europe during the previous year.

Worcester mayor James B. Blake, Massachusetts governor Alexander H. Bullock, Seth Sweetser, William P. Atkinson of the Massachusetts Institute of Technology, Thomas A. Thacher of Yale College, former governor Emory Washburn, congressman George F. Hoar, and probate Judge Henry Chapin rounded out the lineup of speakers.

The day's events were covered to various extents by the Worcester and Boston dailies. Newspapers of the day seldom used the bold banner headlines commonly seen today. Instead, they crowded their pages with complicated headlines stacked one upon the other. Much of the front page was likely to be taken up by advertising. The major news of the day shared the front page of *The Evening Gazette* with pitches for hair restorers, bread and meat cutters, balms, dry goods, insurance and coal.

It required something extraordinary to convince an editor to devote the entire front page to just one news item. But that's just what *The Worcester Daily Spy* did on Nov. 12,

George E. Gladwin (seated to the right of the third row of students), a member of the Institute's original faculty, taught freehand drawing in this room in Boynton Hall. Gladwin's instructional techniques soon became a model for other educators, who frequently visited WPI to observe his classes.



The chemical laboratory in Boynton Hall. It was here that Charles 0. Thompson (seen in the background), the Institute's first president, performed his duties as instructor. Though he was only 31, Thompson earned the trust and respect of the college's trustees, who sent him to Europe to visit technical schools, and gave him a sizeable fund to outfit his lab.

running the story of the opening of WPI under this string of headlines: "Technical Education; The Worcester County Free Institute of Industrial Science; Its Origin, Endowment and Purposes."

That same day the *Gazette* devoted a column on Page 1 and two columns on the following page to the new institute. Readers of a third Worcester paper, *Worcester Palladium*, a weekly, opened the Nov. 18 edition to find a brief apology. "Nothing less than a full report of what was said on the occasion would do justice to the speakers; and such a report we can not publish in our limited space," it said. "The first term of the school commenced last week, with about 50 scholars—as auspicious a beginning, perhaps, as could be expected of an institution whose purpose is peculiar of itself."

An editorial in the *Spy* on Nov. 12 lavished praise on the new college. "The enterprise is a novel one," it said, "differing in some important particulars from any existing institution of kindred aims. The details of the organization have been laboriously perfected by men of great practical wisdom....Worcester is already proud of this school and every addition to the knowledge heretofore possessed by the public of its origin, the fostering care it has received from our best citizens, its present scope and prospects, and its promise of benefits not only to its members but also to the interests of our city and state tends to increase feeling of gratitude to its founder.

"The dedication...which occurred yesterday marks an era in the cause of education in this vicinity," the editorial continued, "and brings into practical operation a scheme of instruction, the need of which has long been felt by all who have been conversant with the needs of the public."

The Boston Daily Journal scolded the organizers of the dedication for the solemnity of the event. "The formal dedication of the Free Institute of Industrial Science in the city of Worcester yesterday marks an era in the march of education which emphatically claims the public attention," it observed. "The advent of the institution—which is a novelty among education appliances—has been a comparatively quiet one, and its dedication was not accompanied by as much parade as generally accompanies affairs of far less magnitude and significance."

But the *Journal* went on to add, "The establishment of such an institution by the munificence of generous men of Worcester County, in a section of New England especially noted for excellence in the mechanical arts, not only reflects honor upon the projects of the enterprise, but will do incalculable good in satisfying, in a measure, a want which has long been felt by young men for a more practical education than our colleges or even scientific schools offered. It unites a machine shop with a scientific school, the theoretical with the practical, and is, we believe, the only free institution of the kind in the world."

When the speeches were over, the students, faculty and guests returned home to contemplate the words and ideas they had heard that day. They may have wondered just how well this bold new experiment would work in practice. They might have taken some comfort in the thoughts of their principal, Charles Thompson, who told the guests on Nov. 11 that "...boys whose faculties are kept constantly alert by the training of the school are in a condition to learn, faster than others, the practical applications of science, and the time spent in the shop will serve the double purpose of instruction and physical exercise and it will be admitted that this form of a manual-labor school is at least an experiment worth trying."

A decade later, Thompson, who would leave the Institute in 1882 to become the first president of Rose Polytechnic Institute, could render at least partial judgement on the success of the experiment over which he had presided. "It has been a period of discovery, settlement, crowded with the perplexities and anxieties inseparable from new enterprises. We have done our best with what we have had during all these 10 busy years of anxious study and experiment."

—The assistance of the American Antiquarian Society, the Worcester Historical Museum and the WPI archives, which provided valuable background material and photographs used in the preparation of this article, is gratefully acknowledged.

Saving the Bride of the Sea

WPI students are helping save the architectural and artistic treasures of this ancient city on the Adriatic.

By Bonnie Gelbwasser

Centuries ago, residents called Venice the Queen of the Adriatic—the bride of the sea. Made up of more than 100 islands in the Lagoon of Venice, the city was a crossroads for seagoing traders who brought gold, spices and fabrics from the port cities of the Near and Far East. Their wealth helped create one of the world's most storied cities—a showplace for brilliant and beautiful art and architecture. Today, 40 percent of Italy's architectural and artistic treasures are located there.

Now, though, the marriage of the sea and its bride is in trouble. The features that have drawn visitors to Venice for so many years —its gondola-filled canals and island-dotted lagoon—may be its undoing. Problems with sewage, with air and water pollution, and with congested waterways are destroying treasures that have endured for centuries and threatening the existence of this jewel of a city.

For two years now, students from WPI have been traveling to Venice to use their knowledge and skills to help this ancient city preserve its heritage. This unusual collaboration grew out of an idea of Fabio Carrera, a native Venetian who received his bachelor's degree in electrical engineering from WPI in 1984 and is now working toward a master's degree in computer science at the Institute.

In 1988 Carrera and several members of the Venetian government and aristocracy established SERENdpt, a foundation dedicated to preserving and enhancing the city. Their aim was to create an organization that could serve as a model for environmental and cultural innovation. Carrera realized that the new foundation could provide opportunities for exciting WPI student projects. In Venice, students could test their technical and decision-making skills by completing projects aimed at finding solutions to the city's environmental problems and at preserving its priceless art and architecture. From Carrera's idea came the Venice Project Program, launched in October 1988.

While nine other foreign universities operate student programs in Venice, "WPI is the only one to cooperate to a great extent with the city's local organizations," says Carrera, who is now coordinator of the project program. "We hold the distinction of being the only college doing projects specifically *for* Venice, and not just *in* Venice."

"We're proud of our students for their hard work," says John F. Zeugner, professor of history at WPI, who was an advisor to student teams in Venice in the summer of 1990. "We know they are making a contribution not only to Venice, but to the world, since so much of what they have discovered and documented can be applied to other nations."

Cruise along the canals of Venice today and you will see the rich legacy of the traders who unloaded and sold their valuable wares here centuries ago. Their palatial homes still line the canals that serve as the city's thoroughfares. The churches and villas built with their wealth—magnificent structures designed by the best architects of the time—are filled with some of the world's great art treasures—works by Titian, Tintoretto, Giorgione and Paolo Veronese.

Renowned for its cultural achievements, for centuries the city was also known as a haven for the freedom of ideas—a heritage reflected in the Venetian university at Padua. The Belgian anatomist Andreas Versalius taught there; William Harvey, an Englishman who discovered how blood circulates, was a graduate. Galileo taught mathematics at Padua for 18 years. In 1609 he had a telescope made at the famous Murano glassworks, located just off Venice's north shore, and took it to the top of the 332-foot-high bell tower of Saint Mark's

Venice, a city filled with ancient treasures, is beset with a number of modern problems. For example, its well-known canals are also the city's sewage system.

Cathedral. There he confirmed that the planets circle the sun.

The decline of Venice as a center of knowledge and art began after the discovery of the Americas toward the end of the 15th century. More recently, a serious threat to this centuries-old city has arisen, one that places the integrity of the city itself—its buildings, its monuments and its very foundation—in jeopardy.

The growth of commerce and industry in the areas surrounding the Venetian lagoon—especially on the industrialized island of Murano—has resulted in severe air and water pollution that threatens the health of residents and endangers the city's artistic and historical artifacts. Increased traffic by vaporetti (water buses) and motorboats create waves that constantly pound and weaken the city's ancient buildings. And, an ancient sewer system that dumps raw waste directly into the canals—a feature that made Venice one of the healthiest cities in the world in its early years—today creates serious environmental health problems.

Pressure is mounting on Venice to solve these problems. That pressure will become more intense when the European Economic Community unites in 1992. Then Italy, like the other 12 EEC nations, will be required to pass and enforce laws that conform with EEC-mandated environmental protection standards.

Since a group of six WPI undergraduates completed the groundbreaking project in the Venice Program, 43 students have undertaken 13 Interactive Qualifying Projects in Venice on such topics as lagoon archaeology, acid fog, pollution on the island of Murano, tidal patterns in the canals, and building restoration and renovation. The IQP, one of three projects required of all undergraduates under the innovative WPI Plan, helps students recognize how their professional work affects society at large.

"By participating in the Venice Program," notes Lee A. Becker, associate professor of computer science and director of the Venice Project Program, "students also gain an appreciation for cultural diversity, which will help them not only professionally, but also as citizens of the world."

During the winter of 1989, Michael Ciacciarelli '91, Brian M. O'Connor '91, Barry B. Sylvia '91 and Steven P. Testa '91 investigated the heights and the flow patterns of tides in the Venetian canals. Using corks, stopwatches and a device they based on a plumb bob, the students took round-the-clock measurements in the canals in all phases of the moon during a two-month period. They discovered that tidal changes don't reverse the flow between the two largest Venetian canals—the Grand and the Giudeccat, causing water to back up in the narrower Grand Canal. Since canals are an integral part of the city's sewage system, carrying waste out into the lagoon, the results indicate that sewage may not be dispersing properly.

While the canal team was at work, William R. LaPrade '91, Ryan S. Marcotte '92 and Patrise G. Puleo '91 discovered that acid fog, not acid rain, is responsible for the destruction of the city's historic buildings and monuments. For their project, which Carrera says is "the first ever to measure the acid pollution levels in ground fog, which occurs frequently in the winter in Venice," the students analyzed fog water that condensed in a specially designed collector they positioned first inside the church of the Miracoli, and later atop the Basilica of San Marco, the church from which Galileo viewed the heavens.

The fog the students collected proved to be 50 percent more acidic than Venetian rain. While they were not able to pinpoint the source of the chemicals that increase the acidity of the fog, the students say they believe the sulfides, sulfates and sulfuric acids are the end products of fossil fuel combustion. Orion Research Inc. in Boston has donated equipment that another group of students will use next year to conduct a follow-up study.

As part of their project, LaPrade, Marcotte and Puleo created a database that includes information about stone decay and restoration. They also wrote a brochure for visitors to the Laboratorio Scientifico della Soprintendenza ai Beni Artistici e Storici di Venezia, which specializes in scientific studies for the restoration of stone frescoes, statues and monuments. The brochure details the history and the work of the laboratory.

In another project conducted over the winter, Nicola McGowan '90, Reinaldo F. Niella '92, Pierre Schrappe '92 and Jennifer Smith '92 studied the archaeological environment of the Lagoon of Venice with the aim of developing technological alternatives that might aid the work of local archaeologists and at the same time build a foundation for future archaeological projects there.

To complete this assignment, the students reviewed state-of-the-art archaeological practices, studied the history of Venice and the physical history of the lagoon, talked with Italian archaeological associations, and

With Fabio Carrera (left) atop Saint Mark's Cathedral are acid fog team members William LaPrade (center) and Patrise Puleo.

completed an overview of the Soprintendenza all'Archeologia, an agency that oversees all of the country's archaeological projects.

The team created a series of booklets on significant archaeological sites around the lagoon. Another booklet compiled by the team provides an overview of current archaeological activity in the lagoon. The students also developed computerized maps and databases for specific archaeological applications.

Carrera says the project was the first attempt to document lagoon archaeology in a comprehensive fashion. To date, he says, there have been few acceptable archaeological studies and little documentation of the archaeological activity in the lagoon—the most complete publication cites only three of the region's 180 archaeological sites. Most of the information the students compiled was previously available only through unofficial sources.

(Left to Right) Jehan Tamboowalla, Rocco Paduano and Jennifer Creamer helped Venetian artisans address pollution problems caused by their work.

Jennifer A. Creamer '92, Rocco Paduano '91, Roberto Reyna '91 and Jehan M. Tamboowalla '92 worked with Stefano Biondi of the Associazione Artigiani di Venezia—an organization that seeks to preserve the traditional practices of the city's artisans while helping them reduce the environmental impacts created by their work. The students helped the group identify, analyze and determine solutions to pollution problems that are endemic to the island of Murano, where many artisans work—especially those who carry on the centuries-old tradition of making fine glass.

Much of the air pollution on the island is caused by furnaces used by artisan shops to melt glass. Artisans who decorate glass with grinding tools generate water pollutants and noise, and all of the glassmaking operations produce waste glass, most of which is not recycled. The goal of this project was to suggest ways that Murano's artisan enterprises might be brought into compliance with the maximum pollution ranges set by the Italian government in anticipation of the 1992 EEC pollution control laws.

The challenge for the WPI students was to develop strategies that would not interfere with or alter the primary techniques used by the glass makers or sacrifice the beauty and strength of their finished products. They also had to address the fact that most of the artisans cannot afford expensive pollution control equipment.

Among the techniques the students recommended was centralizing the making of glass paste, which produces toxic air emissions, in a new facility that would supply this raw material to all of the artisan shops. They also suggested compacting the sandlike primary material used to make glass paste into solid balls before it is introduced into the furnace to prevent the toxic material from becoming airborne, and using filters to screen out air and water pollutants. The students also suggested that the shops consider using the excess heat produced by their furnaces to generate electricity in a process called cogeneration.

Marco Andreoni '91, Orhan Arsel '91 and Samir Sood '91 worked with residents of the island of Sant'Erasmo to investigate the feasibility of implementing organic farming methods there as a way to reduce agricultural pollution, which accounts for approximately 40 percent of the pollution in the lagoon. Another goal of the project was evaluating alternatives to farming that will enable the island to maintain its economic viability as farmers age and sell their farms to developers.

"Sant'Erasmo is an isolated island," notes Arsel. "The people weren't used to foreigners. They were suspicious at first, but after we met with the farmers a couple of times, they became friendly; they gave us so much cheese and wine! They were excited about what we had to say and they wanted to know more.

"When we got there we didn't think we could make a difference. During our discussions we introduced the residents to state-of-the-art technological developments and the benefits of using nonpolluting fertilizers. At the end they were interested in our findings. Our results were published in the Venetian daily newspaper *Il Gazzettino*. The only obstacle we encountered involved language. Although we had an Italian translator from Rome, he had trouble communicating with the farmers because of the differences in dialect."

Other IQP teams working in Venice have created a five-year plan for SERENdpt and built databases of suitable topics for future WPI projects; proposed using solar photovoltaics to light the canals and replace the diesel engines that now power some of the boats that ply the lagoon; created a computer map and an electronic database documenting all of the city's churches; and studied the relocation of the University of Venice to some of the abandoned lagoon islands. A study of the Valle Averto Park in the lagoon, completed in collaboration with Giampaolo Rallo, president of the Venice Chapter of the World Wildlife Fund of Italy, resulted in a recommendation to expand the park throughout the lagoon.

Advisor John Zeugner says the Venice project teams are developing new ideas that may help solve environmental problems in other nations.

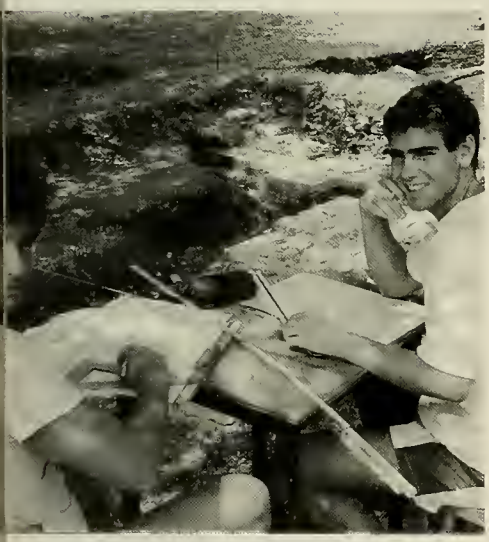
Sean P. Moore '92 went to Venice in the summer of 1990 as part of the team that developed the five-year plan for SERENdpt. "If I had to do it over again, I wouldn't hesitate," he says. "Venice was an amazing place because of its art, its buildings and the fact that we had to go everywhere by foot or boat. While there were quite a few people in the city who spoke English, I found that I could survive in basic Italian about one-third of the way into the nine-week visit."

Many of the Venice project teams have produced booklets describing their results. Some of these publications, which the students often illustrated with photographs and elaborate computer graphics, have been published by the sponsoring agencies.

For example, the artisan's association printed a booklet on the Murano IQP, and the Venetian gas company plans to publish a booklet on tidal flows in the canals.

Several of the IQPs have also been featured in Venetian publications. In a May 22, 1990, article in *Il Gazzettino,* Gino Vitturi, president of the Associazione Artigiani di Venezia, said, "We are particularly proud of having been able to organize this important project with such a prestigious university. This project marks the significance of the changes that are taking place within our association."

In a future IQP, WPI students will survey and map the island of Saint Giacomo in Paludo, using as a model a previous IQP completed on the island of Lazzaretto Nuovo in 1989. The earlier project was "the first to contribute to the real revitalization of a formerly abandoned lagoon island," Carrera says. The 1989 project team presented its results to a group of notables, including the mayor of Venice, Count Girolamo Marcello of SERENdpt., and representatives of UNESCO, the World Wildlife Fund and Save Venice. The island surveys



Reinaldo Niella (left) and Pierre Schrappe at work at one of several archaeological sites they examined on islands in the Lagoon of Venice.

were conducted jointly with students from the University of Virginia Graduate School of Architecture, which regularly sends students to Venice.

Also planned is an IQP in which students will map Venice's public and private gardens and suggest ways to reinstate a self-sufficient park system, and a project that will analyze Venetian museums and develop databases to maintain records of artworks and exhibits. Follow-ups are planned for several projects, including those on lagoon archaeology, organic farming, and solar

With Fabio Carrera are Vineet Jain '92, who looked at the potential use of solar energy in Venice, and Nicola McGowan (right), who studied lagoon archaeology.

electrification of lagoon islands.

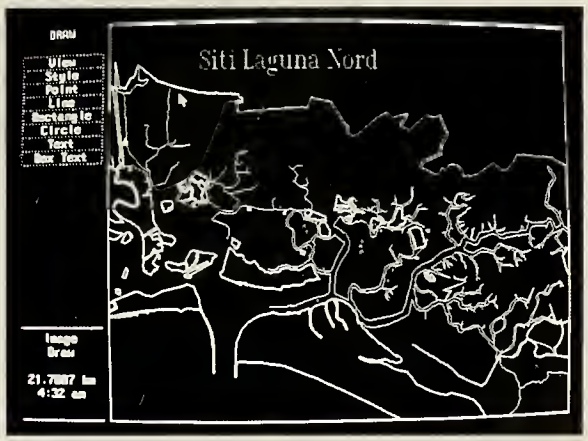
"WPI students have broken new ground in Venice," says John Zeugner. "Studies of lagoon archaeology are helping Italian scientists map and preserve important pieces of Venetian history; the Murano project may significantly reduce pollution-related health and safety conditions while allowing artisans to continue their centuries-old craft. And the fact that WPI students have identified acid fog as the major factor in the erosion of stone buildings and statues may change the way scientists from all over the world address the issue of pollution control.

"Fabio Carrera, more than most people I've met, is driven by a dream: resuscitating and revitalizing his beloved Venice by marrying its extraordinary history to a high-tech future," Zeugner adds. "Carrera and SERENdpt want to make Venice the model for the most advanced techniques of environmental and artistic cultural concerns. To that end, through WPI projects, he is assembling what may already be the most extensive database of environmental/artistic interactions of contemporary Venice in existence."

The Venice IQPs are integral parts of the plan Carrera and SERENdpt have in mind for the rejuvenation of Venice, Zeugner says. "Students at the Venice Project Center find dealing with such a large enterprise, and such a fluid one that changes direction as data accumulates, both a heady and a frustrating experience. As voluminous as some of the projects are—stretching into several volumes of material—every single project team ends up believing there is so much more to do."

Whether the Italian government can summon the resources and the will to deal with the information and recommendations put forward by the WPI student project teams is an open question, Zeugner says. "But, as Carrera often asserts, these changes must ultimately be accomplished, because 'Venice does not belong to Italy; Venice belongs to the world.'"

Carrera himself adds, "If we can help save such a world symbol as the city of Venice, which is truly a concentrated and manageable microcosm of the world's beauty and problems, our efforts could have far-reaching effects on the way future generations treat the rest of the world. We can adopt Venice as a model of what technology can and should do to alleviate the hardships of progress. In this way we can show the path to a more sustainable future."



The lagoon archaeology team developed computerized maps, such as this one, which researchers can use to identify sites of archaeological significance.

Towering Achievements

This summer WPI undergraduates became the first American college students invited to do project work at the Tower of London.

By Bonnie Gelbwasser

Fourteen WPI undergraduates made history this summer in a most appropriate place. The students, advised by Edmund M. Hayes and E. Malcolm Parkinson, professors in WPI's Humanities Department, became the first American undergraduates to collaborate on project work with the staff of the Tower of London.

Hayes and Parkinson, who recently brought three teams of students to London, are active participants in the Humanities Department's Living Museums Program, which provides students with opportunities to work with the documents, artifacts and professional staffs of a number of museums around New England (see related story). The students who worked in London were the first to complete Living Museums Program projects overseas.

The Tower of London projects originated in negotiations begun in the spring of 1989 between Parkinson, Hayes and two key members of the Tower staff—Guy Wilson and Peter Hammond, master and deputy master of the armouries, respectively. "The negotiations began at a time when Wilson and his colleagues were reaching out for more involvement with other institutions and seeking cues from other museums," says Hayes. "In fact, they even came to the United States to study such living museums as Old Sturbridge Village and Plimoth Plantation."

Built by William the Conqueror in the 11th century, the Tower of London is today a museum that houses the main collections of Britain's Royal Armouries.

"The WPI students came in as newcomers to the British educational system and to British museums," Wilson says. "That was a breath of fresh air. They also brought their scientific training to bear on historical subjects. That was incredibly eye-opening."

WPI students undertook three Interactive Qualifying Projects at the Tower over the summer. One group examined the future role of the White Tower, the oldest structure in the Tower complex. A second looked at ways to make the use of artillery understandable to school children. The third team analyzed the history and construction of a coastal fort to help the staff there develop programming for what has become a new branch of the Royal Armouries.

Before they left for London, the students attended a course, taught by Hayes and Parkinson, in which they conducted historical research on the Tower, particularly the White Tower. The students also learned about the recently enacted British Education Reform Act, which emphasizes involv-

With the help of Emma Webb, formerly with the education staff of the Royal Armouries and now a staff member of the Museum of the City of London, and Kyle Lebouitz, Richard Ow finds out firsthand what it was like to wear a full suit of body armor.

ing students in learning, rather than having them simply assimilate facts. That act has also encouraged museums, including the Tower museum, to find ways to make their collections more accessible to visitors.

Founded by William the Conqueror after the Battle of Hastings in 1066, the Tower of London has served as a palace, a prison and a storehouse. Today it is the repository for the British crown jewels. The centerpiece of the 18-acre Tower complex is the White Tower, which now houses the main exhibits of the Royal Armouries—the national armor collection for the United Kingdom, including the spectacular armors of Henry VIII. Parkinson, who served as president of the board of trustees of Worcester's Higgins Armory Museum from 1985 to 1988, calls the Royal Armouries one of the finest arms and armor museums in the world.

The staff of the Royal Armouries focus much of their energies on research into the history of arms and armor, metallurgy, and the military uses to which the items in the collections were put. Recently, Wilson and members of the education staff have, in addition to conserving the artifacts, begun seeking ways to better present the collections to the public.

As part of that effort, a new artillery museum was opened at Fort Nelson, one of a number of fortified installations built in the 19th century to protect the coastal city of Portsmouth, England's primary naval base, from a possible French invasion. A major portion of the Royal Armouries' artillery collection is being moved to Fort Nelson and the education department wants to explain these artifacts to visitors, including the many groups of children who come to the site.

When the unusual, star-shaped Portsmouth forts were constructed, they represented the latest thinking in military strategic defense. Unlike earlier fortifications that stood boldly on high ground, these were sunk below ground level to hide them from the enemy. The forts never saw action.

One project completed over the summer by John S. Adams, Jonas A. Lehmann, Roy E. Martin III, Michael J. Piszczek and Jan Thomas, all members of the Class of 1992, focused on the fort. The Royal Armouries was interested in obtaining the students' perspectives on Fort Nelson's defensive fortifications and artillery, and on the lives and occupations of the volunteers who trained there.

As part of their research, the students traveled to other forts in the area and delved into the collections at the Tower and at a number of London libraries to learn about the military thinking of the period, the design and construction of military installations, and government policy regarding land and sea defenses. The team also became thoroughly familiar with programs currently available to the public at Fort Nelson.

Armed with this knowledge, the students were able to suggest the best ways to modify the programs and what to introduce in the future. They also reorganized an existing slide presentation used at the fort to make it easier for young children to understand. Using their engineering backgrounds, the students wrote simple descriptions of 19th century construction techniques that the museum staff can use when they talk to school groups. They also did a preliminary study to see how computers might be incorporated into the educational programs.

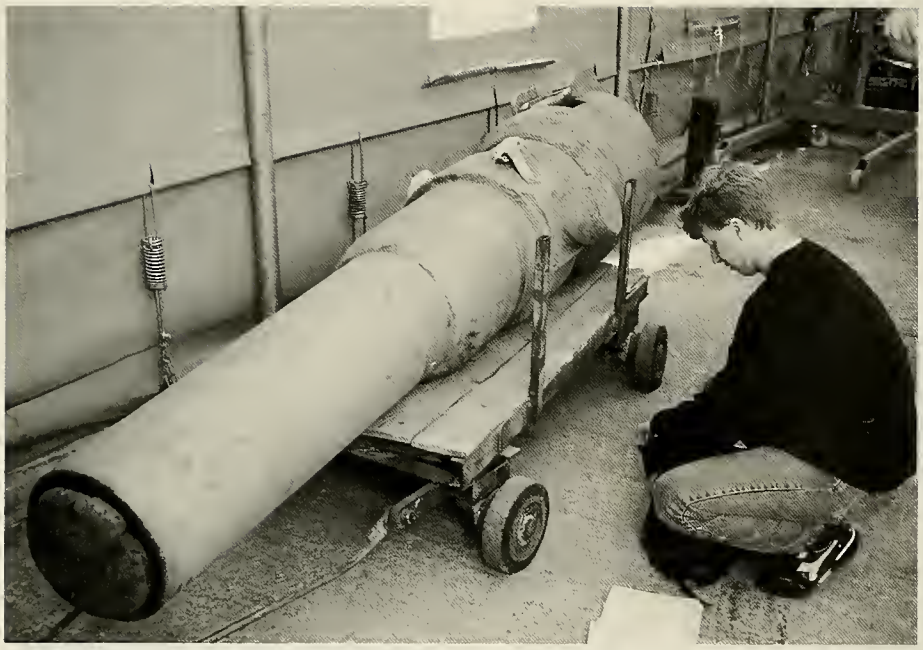
A related project found five students, Gary E. Aspnes '91, Scott W. Biederman '92, Sean C. Emerson '92, Kyle S. Lebouitz '92 and Richard K. Ow '92, working with Graeme Rimer, keeper of weapons at the Royal Armouries. For their projects, the students developed lesson plans to teach visitors about the Armstrong Cannon, a 7-inch rifled breech-loader that has been moved from the Tower to Fort Nelson.

"Our goal was to research the history of the cannon and to use the weapon to illustrate a number of scientific principles for children," says Biederman. "The Armstrong, which was once actually housed at Fort Nelson, weighs about 4 tons.

"We created lesson plans based on specific themes and wrote special handouts. The children will be able to touch the cannon and see, for example, that the rust marks on the inside indicate that it was made by coiling, and that the rifling grooves that spin the shell are there to make it fly further and more accurately."

"We were delighted with the students' report," says Rimer. "We found it to be extremely useful. Our intention was that the report should be gradually integrated into the artillery program and should help us in the development of our satellite museum at the Royal Armouries. As we occupy more and more of the site, we will use more and more of the students' suggestions. We're very keen to use them.

Some of the students who completed projects in London last summer: (left to right) Gary Aspnes, S. Scott Emus, Scott Biederman, Sean Emerson and Michael Piszczek.



Kyle Lebouitz studies the 4-ton Armstrong Cannon. He was part of a team of students who developed ways to teach visitors to Fort Nelson about the history of the weapon and to use the cannon to illustrate scientific principles.

Richard Ow tries out a WWI periscope at the British War Museum, one of a number of museums students visited to learn about effective ways to display historical artifacts.

"The gun they concentrated on is now complete and will be demonstrated in our next season—April to October 1991. We not only have a public visitors' program but an educational program, as well, and we will incorporate quite a number of their suggestions into this program. I would be more than happy to work with such a group again."

The third project completed during the summer focused on the Tower of London's most famous structure, the White Tower, which Hayes and Parkinson note is "perhaps the most important medieval military building remaining in Europe." The White Tower's battlements soar 90 feet above the ground and its walls are 15 feet thick. For the first centuries of its existence it served as the fortified residence from which the king maintained control of the country.

Today, because it is a museum for the Royal Armouries, much of the early Norman architecture is hidden from view behind aluminum and glass display cabinets, linoleum floor panels and tented ceilings. The rooms are filled to overflowing with shields, guns, crossbows and animal heads.

With the emphasis on the collection rather than the building, visitors often find it difficult to understand the nature of the White Tower itself. One of the goals of a project completed by S. Scott Emus '91, David R. Flinton '92, Megan R. Moore '91 and Shellee A. Morehead '92 was to make the structure of the Tower more visible—and comprehensible—to these museumgoers.

Working closely with Sue Wilkinson, deputy education officer, and archaeologist Geoffrey Parnell, inspector of historical sites for the English Heritage Society, the students developed strategies for organizing and improving displays and suggested ways the museum can restore the structure of the Tower to its original appearance.

"The students had to apply their knowledge of the engineering that went into the construction of the White Tower," says Hayes. "Because they were engineering and science students, they could see ways to make this building more accessible to the public. This was extremely important to the staff."

"The staff at the Tower had never had a report on the building done before," says David Flinton. "It was a real challenge for us. Because we were in London for such a short time we chose to concentrate on the 11th century, when the Tower was built, and on the 18th century, when it changed from a palace to a storage center and office building.

"It was interesting to see how the technical and analytical skills you learn as an engineer come into play in every aspect of life. We were working on a 900-year-old building and it seemed at first that our project had very little to do with engineering. But we studied 11th century construction methods and tools, and discovered how some of the tools are still being used today. The carpenters who built the White Tower were really quite advanced for their time."

With Geoffrey Parnell as their expert guide, the students made on-site visits to other historic buildings every Tuesday to see how they were presented to the public. Their goal was to develop ways to set up the Tower collections so they will not detract from the building that houses them. "We wanted visitors to get a sense of what it was like to be in an 11th century castle," Flinton says.

Wilkinson says her agency had never worked with engineering students before. "The experience with the WPI students was very stimulating from both sides because the students were learning about the Tower, but were also introducing the educational staff to the ways in which we could apply scientific techniques and principles at a site like this and at Fort Nelson. Their research will be useful to our teachers, because they pulled a lot of information together in an easily accessible format.

"It was the students' enthusiasm and commitment to the project that really impressed me," she adds. "There was a level of sheer hard work that was very impressive and it was very stimulating discussing things with them."

"The success of the projects at the prestigious Royal Armouries demonstrates the effectiveness of WPI students in an international setting," say Hayes and Parkinson. "It has convinced the faculty that future Living Museums Program projects abroad should be equally successful, providing educational value to the students and direct value to the museums in their task of conserving and transmitting culture."

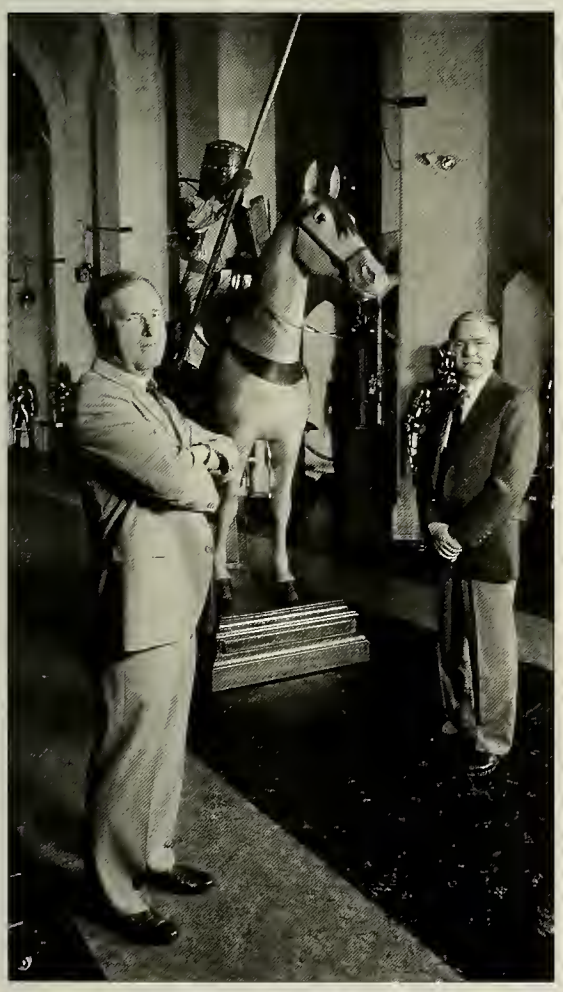
Living Museums Program Shows Students A Different World

When E. Malcolm Parkinson and James P. Hanlan, both associate professors of history, and a few of their colleagues from the Institute's Humanities Department set out in 1976 to create the Living Museums Program, they realized they had no model to follow. No other college in the country had ever attempted a similar collaboration with a museum.

"Obviously we did not intend for our students to be interns at the museum," Parkinson says, "nor did we think they would be interested in learning the business of running a museum or in performing routine tasks for the museum staff. What we needed were specific projects that museums needed done, but which were also academically appropriate for our students."

With support from a Mellon Foundation grant, the founders of the Living Museums Program visited museums around the region and quickly realized that many of these institutions were eager to take advantage of the kind of collaboration the program promised.

During the 1977-78 academic year, the first group of projects was completed at the Peabody Museum in Salem, Mass., the Salem Maritime National Historic Site, and the Merrimack Valley Textile Museum in North Andover, Mass. Since then, more than 300 students have completed projects at about 15 New England museums.



JANET WOODCOCK

Living Museums Program founder E. Malcolm Parkinson (right) with Edmund Hayes in the Great Hall of the Higgins Armory Museum in Worcester.

From the start, Parkinson says, museums have proven ideal locations for conducting Interactive Qualifying Projects, the most distinctive element of the college's innovative undergraduate program, the WPI Plan. The IQP requires students to relate science and technology to some aspect of society and human life, he explains. "What better place to undertake such a task than at a museum?"

The museums participating in the Living Museums Program have offered a wide variety of focuses and environments for student projects, ranging from the collection of historic European weaponry in the Higgins Armory Museum in Worcester, to the large-scale recreations of early American life at Old Sturbridge Village and Mystic Seaport, to the Hartford, Conn., home of American humorist Mark Twain.

Not surprisingly, the projects conducted at these museums have covered a great deal of historical ground. For the Higgins Armory Museum, for example, students have studied the evolution of the sword, designed and constructed an exhibit on foot combat in the 15th and 16th centuries, and evaluated the potential impact on young visitors of a proposed exhibit on torture.

At the Slater Mill National Historic Site in Rhode Island, which commemorates the origins of the American Industrial Revolution, WPI students have conducted an oral history of Rhode Island textile workers and examined the cotton industry in that state. Other project teams have constructed a simulator to teach visitors to the Peabody Museum how ships were sailed in the 19th century; looked at cider making—a widespread "home industry" in New England—for Old Sturbridge Village; and developed an exhibit—including an animated model—on continental drift for the New England Science Center.

As the program enters its second decade, it is picking up new momentum, attracting new faculty advisors (including Humanities Department faculty members Steven Bullock, Edmund Hayes, Kent Ljungquist, Wesley Mott and Michael Sokal) and expanding to new museums, notes Parkinson. In recent months, in addition to the projects at the Tower of London, students have worked for the first time at the Fruitlands Museum, which preserves the 19th century utopian community of Bronson Alcott in Harvard, Mass.

The program has been so successful," Hanlan says, "because it offers students an opportunity to enter a world quite different from the technical world they experience as students or the professional world they will know as graduates. It permits them to bring their technical knowledge to bear on problems deeply rooted in the issues and concerns that face us as a society. And, after all, that's what the IQP is really all about."

Notes From Europe

Snowy nights in Moscow, cathedrals in Madrid, and bullet-pocked walls in Romania were all part of a recent tour by WPI's musical groups.

By Ruth Trask

Last March the members of every WPI student musical group packed up their instruments and their bags and headed for Europe. For 10 days, some 120 musicians, faculty members and alumni toured the Soviet Union and Spain, winning hundreds of new friends along the way with their performances and their exuberance. It was the first time all of WPI's musical groups performed abroad at the same time.

Some of the students also made a bit of history. Following several days in the Soviet Union, 80 of the WPI musicians became the first American tour group to visit Romania after the downfall of dictator Nicolae Ceausescu.

"The people were friendly, but we were happy that we had only one concert scheduled in Bucharest," says Douglas G. Weeks, administrator of applied music at WPI and director of or advisor to the Brass Choir, Concert Band, Saxophone Ensemble, Medwin String Ensemble and Woodwind Ensemble. "There was a sense of unrest. We're not accustomed, in our country, to seeing bullet holes in buildings." Although the musicians were greeted warmly, Weeks says they were relieved when it was time to go.

Adds Richard G. Falco, visiting lecturer of music and director of the WPI Stage Band, Jazz Ensemble and Jazz Workshop, "Bucharest is a beautiful city, but we were nervous visitors." The Stage Band's performance was sponsored by the president of a local Romanian jazz society. According to Falco, though jazz was officially outlawed in Romania for some time, it has always had a strong following among the Romanian people.

Prior to their one-night stand in Bucharest, the WPI musicians, including the Women's Chorale, directed by Malama Robbins, adjunct associate professor of music, and Brass Choir alumni Richard Correia '86 and Robert D. Edelman '86, played to standing-room-only audiences in the Soviet Union. "The reception and warmth of the people were just overwhelming," Weeks says.

The Soviet audiences were surprised to learn that the WPI musicians were also engineers, seeming to find the notion of engineers being able to perform a wide repertoire of music almost unthinkable. "The mayor of Pushkin (Worcester's sister city in the U.S.S.R.), after hearing our performance, said the Soviets need to broaden their educational system," Weeks reports. In addition to Pushkin, the WPI musicians visited and performed in Moscow, Leningrad and Minsk.

John A. MacNeill '92 and Troy K. Nielsen '91, members of the Stage Band and the Jazz Ensemble, kept a diary of their experiences during the Soviet tour. The diary was published in *Newspeak*, WPI's student newspaper, shortly after the groups returned to the U.S. Following are excerpts from their account:

Sunday, March 4

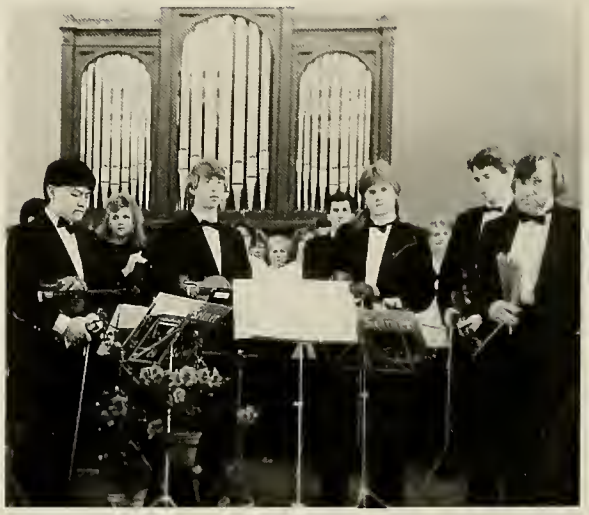
Today we saw Moscow in all its glory. It was cold, windy and snowing—a typical March day. Among the sights we saw were the Bolshoi Theater, the University of Moscow, the parliament building, and many "palaces"—the Russian term for large yellow buildings. We went to the Metro, Moscow's largest hotel, to do some shopping in the Beriozka—stores that accept American money.

At the end of our tour we visited Red Square, a large, beautiful plaza where St. Basil's Cathedral and Lenin's Tomb are located. In the U.S.S.R., Lenin is virtually an icon, and his tomb, where the former leader's body is preserved for eternity in a glass case, is constantly guarded by Soviet soldiers. Visiting the tomb is an eerie experience. You can sense the deep respect the Soviet people have for this man.

Tonight we gave the first performance that included all the musical groups. The reception was incredible. The children in the audience gave the band members carnations as we played. After the performance, we were swarmed by people who wanted to make some kind of contact with Americans.

Monday, March 5

The Stage Band had an early concert today at a Moscow college of music. We had all agreed in advance that the music must be of high quality whenever any of the groups performed for Russian musicians. After all, we were likely to be the only Americans some of these musicians had ever seen in performance. Needless to say, the performance went very well, and the reception was excellent. The Russians were very generous with gifts, such as pins and postcards.



With Douglas Weeks (far right) at the Pushkin Music School are Medwin String Ensemble members (l to r) Hiroshi Otsuka '90, Jonathan J. Stott '93, Christopher R. Trotta '92 and Scott M. Sheehan '93.

With members of the Regis College Glee Club at the Escorial, the 16th century palace-monastery-mausoleum built by Philip II northwest of Madrid, are Jean Pierre Trevisani '90, Jonathan O. Jacobson '93, Michael J. Wrobleski '91 and Thomas P. Lindgren '92.

We did some more sightseeing in the afternoon, including a tour of the Kremlin—the symbolic hub of the Russian empire. Inside, surrounded by massive brick walls and towers, there are buildings that range from ancient Italian-style cathedrals from the time of Ivan the Terrible, to modern government buildings and museums.

Later in the evening we boarded a train to Minsk—a difficult task, especially with 120 clueless people trying to lug hundreds of pieces of luggage and equipment through a narrow corridor. With a bit of luck, however, everything got thrown on—literally.

Tuesday, March 6

Minsk is a beautiful, modern city that, overall, seems much cleaner than Moscow. We got to our hotel, which had the appearance of a first-class establishment, and were fed right away. We liked that.

After lunch we went sightseeing. Of special note was the World War II Memorial, which houses an eternal flame. Like Lenin's Tomb, this was guarded by soldiers. We hit the shops next. The most famous department store in the U.S.S.R. is Gum (pronounced "goom"), a shopping mainstay for Soviet citizens. Here the power of the American dollar can be seen. For example, one can purchase a fur hat for about 20 rubles—equivalent to two American dollars.

This evening the Brass Choir and Women's Chorale gave a televised concert at a conservatory. In the audience were a number of Soviet music students. There was an air of pleasant dignity to the evening, as the audience showed its appreciation for the performances.

While Weeks, Falco, Robbins and their groups were touring in the Soviet Bloc, 33 members of the WPI Glee Club, led by Louis J. Curran Jr., associate professor of music, performed in Spain. The group was accompanied by the Regis College Glee Club. The Baker's Dozen, a subgroup of the WPI Glee Club, also performed during the tour under the direction of Bruce A. MacWilliam '75. Glee Club alumnus Mark R.A. Beckwith '83 performed with the group.

"While we were in Spain," Curran says, "we were the official guests of the Ministry of Culture and had the representative of the District of Toledo as our host. The housing, especially in Madrid, was spectacular. Looking out the large picture windows of our hotels at the ancient walled cities of Segovia and Toledo was something we will all remember."

The Glee Club gave its first performance in the Basilica de Santa Cruz in Madrid, where the sound reportedly "goes on forever." Its next concert was set in the ancient Iglesia de San Milan in Segovia. During both concerts, the chorus performed a selection of American spirituals. Curran says the audiences enjoyed them so much they asked for encores.

"Strangely enough, we were asked to take mostly American folk music or American spirituals with us to perform in Spain," reports Curran, who says Spanish audiences clap politely when their own music is sung, but yell and scream when they listen to the rhythms and energy of "Ezekiel Saw de Wheel" or "Ain-a-That Good News."

"Our final concert, at the Auditorio de Caja Rural in Toledo, was especially memorable," says Curran. "Following a well-received performance, we were given a large and festive farewell dinner in the Palacio de Fuensalida, where we were entertained royally by Spanish flamenco music and dancers." At one point, Curran says, several WPI singers were given impromptu dance lessons by the flamenco group.

As parting gifts, the Spanish minister of culture presented ceremonial Toledo steel swords to the directors of the Regis and WPI Glee Clubs. "He unofficially dubbed us 'Knights of Toledo,'" says Curran. "An unforgettable finish to a highly successful tour."

Jack Pobuk Finds Paradise Through the Peace Corps

Not everyone who joins the Peace Corps ends up running his own business in paradise. Jack Pobuk '80 is a notable exception. He is the only engineer consultant on a lush tropical island in the Pacific—at least for the moment.

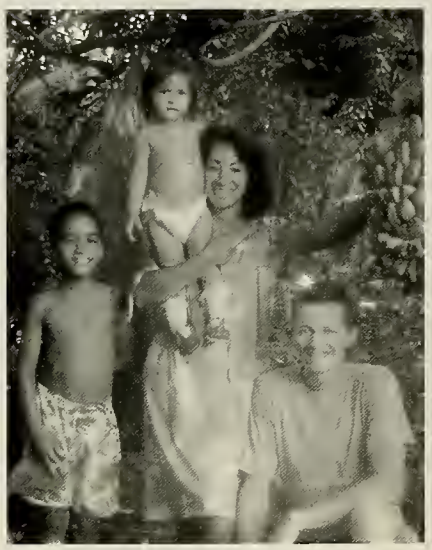
A professional engineer, Pobuk recently returned to WPI to look for a fellow civil engineer to join him in his Western Pacific consulting firm. "He'll have to be independent and have a sense of humor and adventure," says Pobuk, who could well be describing himself. "My business is on Pohnpei Island in Micronesia, 1,000 miles east of Guam. It's about as remote as you can get."

Pobuk arrived in Kolonia, Pohnpei, as a Peace Corps volunteer shortly after he graduated from WPI. He was assigned to work for the island public works department. "It was my job to train local citizens in water and wastewater treatment," he says. "I worked with the Peace Corps for two years for $237 a month—not much money, but you don't need a lot of money to live well in Micronesia."

Eight years ago Pobuk took his Peace Corps savings and started his own private consulting firm on Pohnpei. "As the only engineer in private practice on the island, I am employed primarily by the local government," he reports. "Kolonia has grown to a community of 10,000 and there is plenty of work to be done."

Pobuk's company is helping the municipal government expand the island's internal and external business by making a number of technical and engineering improvements. Although electricity is now available to almost everyone, there is a need for water and wastewater systems. "That's where I come in," he says. "I design water supply, sewer and sanitation projects."

The improvement projects are taking on a special urgency, he says, since tourists are beginning to discover the beauty of Pohnpei. "We have an airfield that can accommodate 727s," he says. "Many travelers, especially from Japan, fly in to scuba dive. Speaking from experience, the diving off Pohnpei is fantastic. The water is crystal clear and the reefs are exceptional."



Framed by tropical vegetation are Jack Pobuk '80, his wife, Roselt, Roselt's cousin Ordnance (standing) and daughter Katie.

A small islet in Pohnpei Lagoon. The crystal clear waters around Pohnpei lure vacationers to this island paradise.

Pobuk is a one-man chamber of commerce when it comes to describing the benefits and citing the history of his adopted island. "Everything grows on Pohnpei," he says. "We have 200 inches of rain annually, plus lots of sun. Fruit thrives on its own. Farmers grow crops under the trees in 'jungle' farms."

There are, he adds, plenty of bananas and fish. There are also many types of coconut trees. Certain young coconuts are best for drinking, he explains. "The old, hard ones—like the ones sold in supermarkets in the U.S.—are saved for pig food."

According to Pobuk, there are no beaches on the island, which includes among its topographical features an extinct volcano and a thick rain jungle. "It is ringed by a mangrove swamp that is, in turn, edged by a coral reef and a lagoon," he says.

Pohnpei is part of the Federated States of Micronesia. During World War II it was in Japanese hands. From the end of the war until 1986 it was a trust of the United States. The U.S. still gives financial aid to the island and controls the waters around it. The island's 25,000 inhabitants include 200 Filipinos, several dozen Americans and a number of Japanese. "Foreigners are not allowed to own land," Pobuk notes.

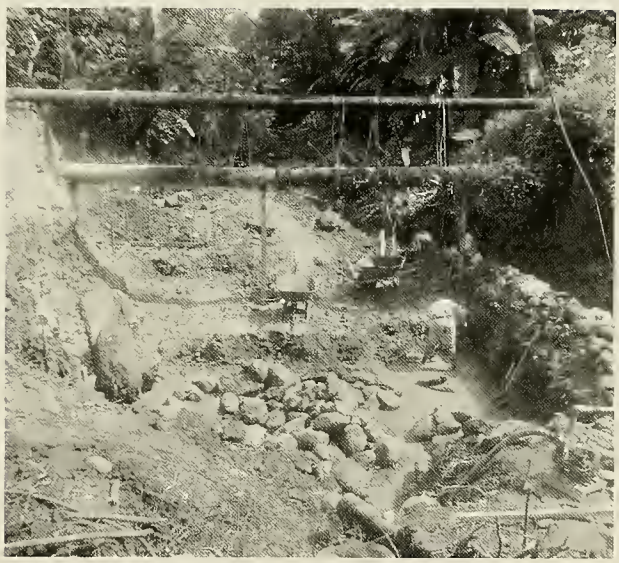
"When I first arrived on the island, I learned that the U.S. had begun paving roads and developing water resources," he says. "The money coming in for infrastructure projects meant there was a big demand for civil engineering work, but no locally based engineers to do it."

Although Pohnpei is more than half a world away from his native Gardner, Mass., Pobuk says he has no plans to move back to New England, especially now that his business is expanding. Last summer, though, he brought his wife, Roselt, a native of the island, and their two children—Katie, 3, and John, seven months—to see Gardner for the first time.

When Pobuk visits the U.S., he is occasionally asked about his fair complexion, which shows no hint of a tan. "I learned long ago that the sun is too hot in the tropics," he says. "No one stays out under the sun unless they have to. If you show a picture of people sunbathing to islanders, they laugh, wondering how those 'crazy' people can stand sleeping in the sun."

—Ruth Trask

As the only civil engineering firm on the island of Pohnpei (bottom photo), Pobuk's company is kept busy with a variety of government projects.



(Clockwise from top). A water pipe crosses a river in Kolonia. Work progresses on a new road. Workers build a bridge over a small stream. Photos by Jack Pobuk.

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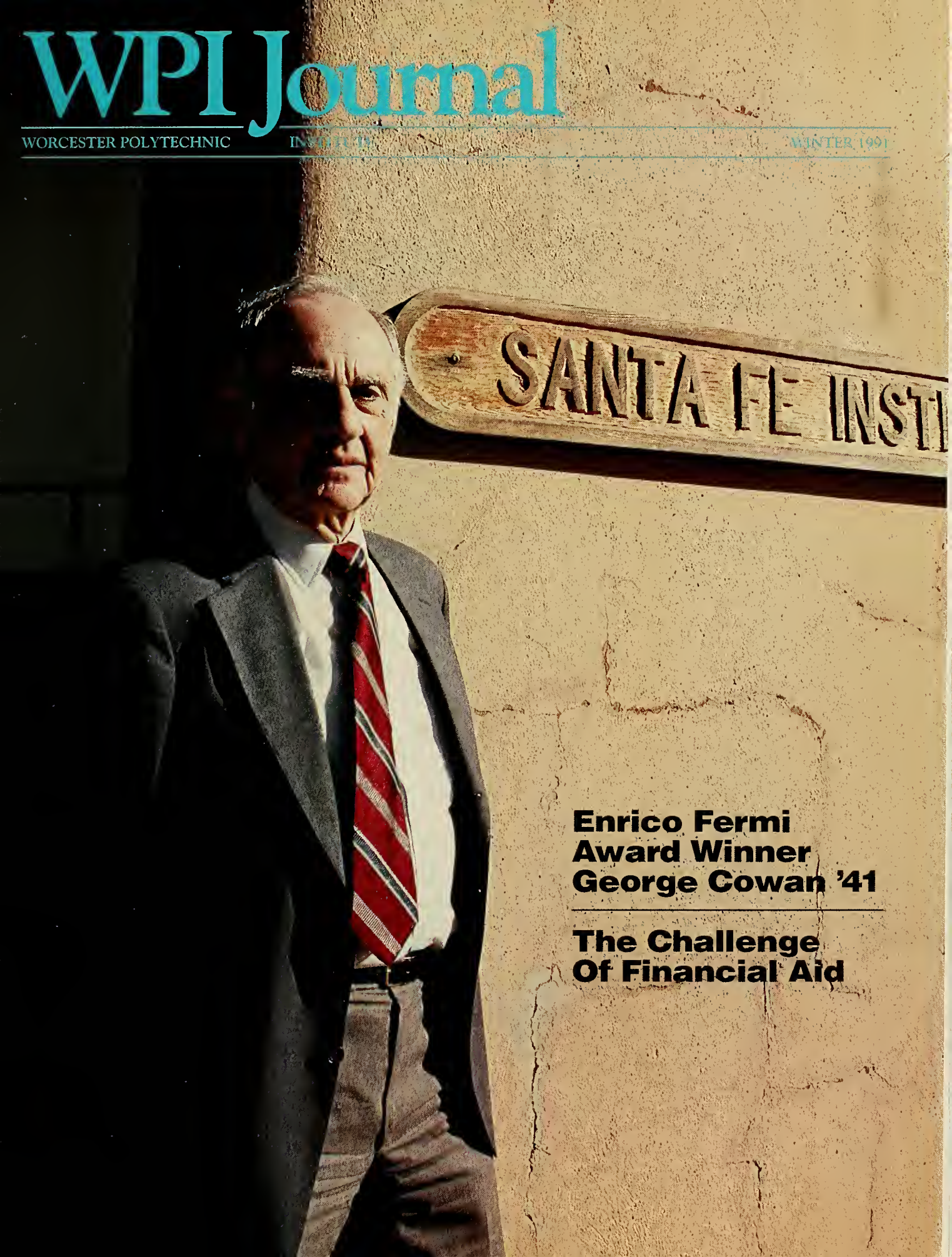

Enrico Fermi Award Winner George Cowan '41

The Challenge Of Financial Aid

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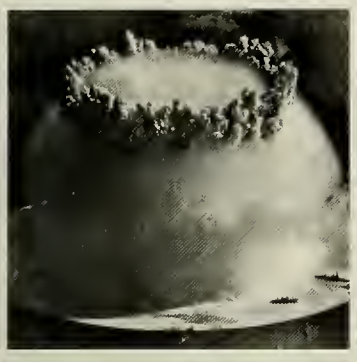

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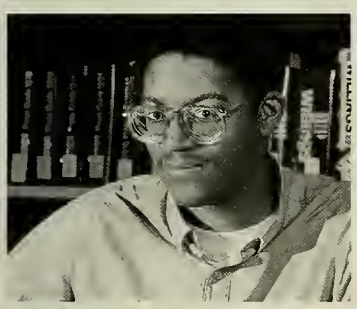

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Rising financial aid costs are placing a strain on WPI's budget. What's behind the growing gap between the Institute's cost and the ability of its students to pay, and what can the college do about it?

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WPI's biochemical engineers are working to harness the microscopic assembly lines inside living cells, and to separate and purify the valuable products those cells manufacture.

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Front Cover: George Cowan '41. Story on page 4. Photo by Michael Dorsey. **Opposite:** The west end of Atwater Kent Laboratories as it looked before renovations transformed the building a decade ago. WPI's trolley test car entered the building through theses doors. **Back Cover:** Alden Memorial Auditorium emerges from a winter storm. Later this year, work will get under way to turn this 50-year-old building into a modern home for the performing arts. Photo by Robert S. Arnold.

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Information Overload

As we're frequently reminded, this is the Age of Information. Today we're bombarded by all sorts of information that arrives at our doorsteps or over the electronic transoms of our personal computers. At times it seems too much to handle, and we begin to feel as if we're drowning in the very information that's supposed to improve and enrich our lives.

There may be a good reason for that feeling, notes George Cowan '41, president of the Santa Fe Institute and the subject of our cover story. Each level of organization in the universe, Cowan says, has a characteristic time frame in which information is exchanged. At the lowest known level (quarks), information passes back and forth in about 10^{-30} seconds. Molecules operate at about 10^{-8} second. Information moves between parts of the human body in anywhere from 10^{-3} seconds to one second.

At the top of the information ladder is human society. Historically, information has moved slowly among human beings, with news taking weeks or months to travel from family to family or village to village. But since Gutenberg developed movable type in the 15th century, people have been coming up with faster and faster ways to generate and disseminate information. Today, with communications satellites, fax machines and computer networks, information can travel the globe in seconds.

As an example of what can happen when people have too much information and too little time to deal with it, Cowan points to the *U.S.S. Vincennes*, the guided missile cruiser that mistakenly shot down a civilian airliner in 1989. "That ship had a sophisticated information system in which sailors acted as the processors," Cowan says. "They stood in front of consoles calling out information to each other about the target's speed, bearing and so forth. Someone had to assimilate that information and arrive at a conclusion in three minutes. Advanced technology like this can produce information poison. Just like rattlesnake venom, it's paralyzing."

The answer to the information glut may be further advances in information processing technology, a focus of work at Cowan's institute. Such techniques as parallel processing, artificial intelligence and fuzzy logic may make computers better able to sort out information and help us attend to the things that really matter—much as the human brain does with the overwhelming flow of information it receives from the nervous system. In the meantime, we'll just have to try to keep our heads above water.

—Michael Dorsey

Letters to the Editor. . .

Wary of "Big Time" Sports

After reading your Summer 1990 issue, I propose that WPI not get carried away with the "big sports" scene. It will detract from the scholastic effort. Big sports also involves a lot of money, which you are now asking the alumni to provide—just like all the other big sports schools.

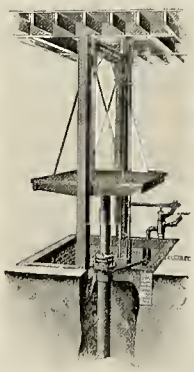
There is nothing wrong with athletics for fitness, and I recommend that school athletics generally be limited to individual sports, not team sports.

WPI has a great tradition and reputation as a hands-on school for mechanical people, and it ought to stay that way. Big sports will ruin it.

William E. Eaton '38
Eugene, Ore.

Washburn's Commercial Past

In "Timeline" (Summer 1990), Neil Norum had the Washburn Shops shutting down commercial operation in 1896. That's not Neil's fault, but the fault of some of the written WPI history.



The shops ceased commercial operation nearer 1955, when L. Earl Fairbanks '51 and Kenneth Fowler '41 sold the rights to the last remaining products—the Rawson Coupling, the Worcester Drill Grinder and the Worcester Drawing Stand.

The Rawson Coupling, an automatic centrifugal clutch, was invented and patented by Louis W. Rawson '96 in the 1930s. J. Adam Holbrook '38 applied the coupling to the helicopter and obtained several additional patents in the 1940s. This application was used by Sikorsky, Kaman and Kellert, to name a few.

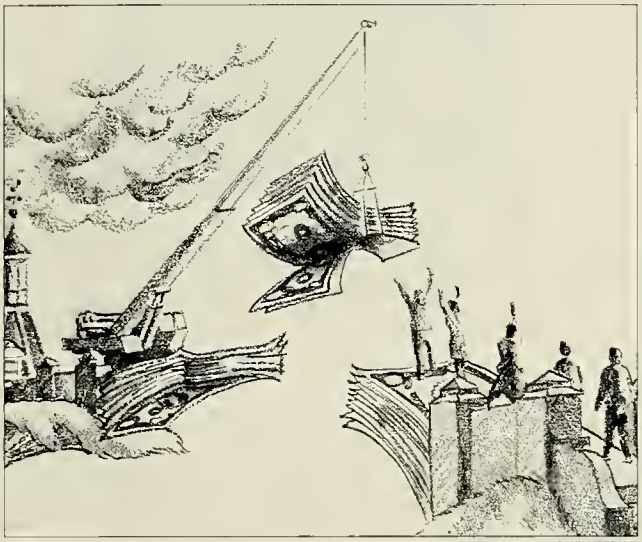
The shops operated a full-blown commercial foundry for Worcester industries. The foundry was pouring at least five days a week, 52 weeks each year, between 1938 and 1942, when I was a student. That scale of operation continued until 1945.

At that point the work was curtailed, and the foundry's output was limited to special castings for the shop's own products, and for companies like O.S. Walker, Rockwood Sprinkler and Morgan Construction. Superintendents after Milton Higgins included Rawson, Burton L. Gray (promoted from foundry foreman), Holbrook, and Fairbanks (the last superintendent). I served as superintendent from 1946 to 1954. Kenneth Fowler and Warren Zepp '42 shared the responsibility while I was on Navy active duty during the Korean War from 1951 to 1953.

John M. Bartlett Jr. '42
North Falmouth, Mass.

The Challenge of Financial Aid

As you will read in the article beginning on page 12, financial aid has played an important role in helping WPI achieve its mission to educate talented young people in science, technology and management throughout the college's history. In recent years, however, the price increases necessary to improve our quality have stretched the ability of our students and their families to pay for a WPI education, at the same time that external sources of financial aid have been shrinking. As a result, we now face a challenge to our future financial viability.



PAUL METCALF

At their October 1990 meeting, the WPI trustees learned that a 6 percent increase in undergraduate tuition proposed for the 1991-92 academic year would yield only a 1 percent increase in tuition revenue after the college meets the increased need for unrestricted financial aid that would result from that tuition increase. Moreover, similar tuition increases in subsequent years would actually result in a *decrease* in net tuition revenue.

Since net undergraduate tuition revenue covers two-thirds of our academic operating budget, this is a matter of grave concern. Conservative projections suggest that we face a shortfall, before corrective actions, of almost 6 percent in the operating budget for 1991-92 and beyond. Given the long-term nature of our employment relationships—to say nothing of our commitment to provide academic programs for our students—6 percent is an enormous gap.

This situation is not a complete surprise. The need-blind admissions policy we introduced four years ago has helped maintain our enrollments and promote diversity in our student body. But reductions in some federal and state financial aid programs, and a decline in the ability of the average parent to contribute to the cost of a college education, have made this policy more expensive than originally forecast. Unfortunately, the simultaneous decline in the number of high school graduates and in student interest in science and technology has reduced the pool from which we draw our applicants. Consequently, it would not be an effective strategy to try to admit more students who have the ability to pay.

These problems are not peculiar to WPI. All private (and many public) institutions, if not there already, will soon find themselves caught in this inexorable squeeze on net tuition revenue. But given the relatively high costs associated with our distinctive, high-quality educational program, and the limited resources of our traditionally middle-class applicants, we are experiencing more dramatic difficulty than most. In the fullness of time, society will have to face up to its responsibility to preserve the extraordinary quality and value of the independent sector of higher education. But because we are on the leading edge of this phenomenon, if our immediate problem is to be solved, we must solve it ourselves.

WPI is a relatively small school that offers a distinctive program of excellent quality in an attractive setting. Clearly, there should be more than enough potential applicants—across the nation and around the world—with the ability to pay WPI's prices. In fact, we know that applicants with the ability to pay represent a larger percentage of our applicant pool than of the group of students who actually enroll.

In the spring of 1986, when WPI was looking ahead to a predicted decline in enrollment due to changes in demographics and student interest, we appointed an enrollment task force. Under the direction of trustee Peter Horstmann, and with its membership drawn from the Board of Trustees, faculty, alumni, students and staff, the task force provided the Institute with useful advice that has been an important factor in the success we've realized in admissions since then.

Given that success, and the new challenges we face, the college launched the Marketing Task Force in the fall of 1990. Led by trustee John Nelson, that group is considering how we might better market WPI to prospective students—and their families—who are better able to pay for WPI's quality.

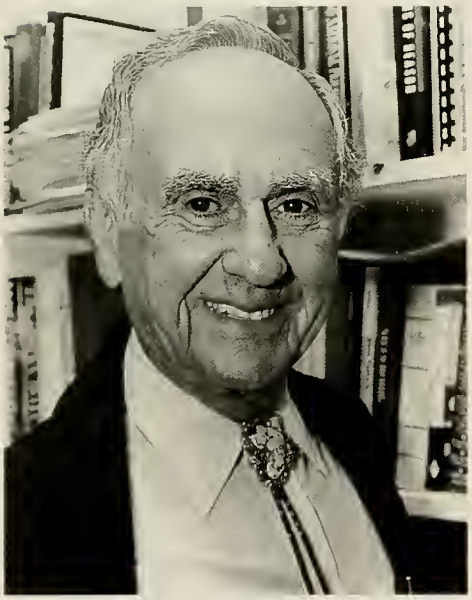
In the months and years ahead we must develop short- and long-term solutions to this financial aid challenge. In the short term, we must increase the productivity of our faculty and staff and reduce other expenses so we can continue to enhance our quality while we bring our expenses in line with our revenues. In the longer term, we will work with the Marketing Task Force and with our Admissions Office to improve our net tuition revenue, thereby helping to achieve revenue-expense equilibrium. An important aspect of this process will be restraining our price increases to improve our affordability in the middle-income markets. It is a daunting challenge, to be sure, but by solving it we will assure that WPI remains a vital and dynamic institution as we approach the next millenium.

—Jon C. Strauss

Strauss is president of WPI.

CHAIN REACTIONS

By Michael Dorsey



CARY HERZ

George Cowan's remarkable career in science has taken him from the heart of the Manhattan Project to the frontiers of economics research.

In early 1939, George A. Cowan '41 was a sophomore at WPI, studying physics in Morton Masius' classroom. One day, before class, he clipped an article out of a local newspaper and brought it in for Masius to read. According to the article, scientists in Europe had published evidence that atoms of uranium can absorb neutrons and split into fragments, a process they called nuclear fission. This process, the scientists announced, turned a tiny fragment of the nucleus into energy according to Albert Einstein's elegant equation $E = MC^2$.

"We had a lecture a few days later," Cowan remembers, "on the difficulty of producing any significant amount of power this way. What was left out of that lecture—what Masius didn't know—was how many neutrons were made per fission. He assumed there would be no multiplication, but multiplication does, in fact, occur."

Multiplication—the release of more than one neutron by each fissioning uranium atom—is what makes a nuclear chain reaction possible. Each of the released neutrons can cause a new fission and each newly split uranium atom will, in turn, release multiple neutrons, each of which can trigger still more fissions, and so on. In short order, what begins with the splitting of a few atoms can spread through a mass of uranium like wildfire, unleashing progressively greater amounts of energy.

The headlines in the morning paper on that winter day chronicled another, more ominous, course of history. Having occupied Czechoslovakia, Adolph Hitler's troops were preparing to invade Bohemia and Moravia, small steps on a road that would lead by year's end to the start of the Second World War.

Within six years, these two streams of events—global war and the quest to harness nuclear fission—would intersect spectacularly in a remote corner of the New Mexico desert. While he didn't know it then, George Cowan would soon find himself squarely at that intersection, working as part of a team of scientists racing against the clock—and the belief that Germany was in the lead—to create the world's first atomic bomb, a weapon that would ultimately bring World War II to an end.

Cowan's work on the Manhattan Project was just the start of a career that has spanned nearly 50 years. In that time he has made seminal contributions to the field of radiochemistry, discoveries that have enabled scientists to understand what happens in the microseconds after a nuclear bomb detonates, to assess the capabilities of nuclear weapons tested by foreign powers thousands of miles away, and to study such diverse phenomena as solar neutrinos and a naturally occurring nuclear reactor.

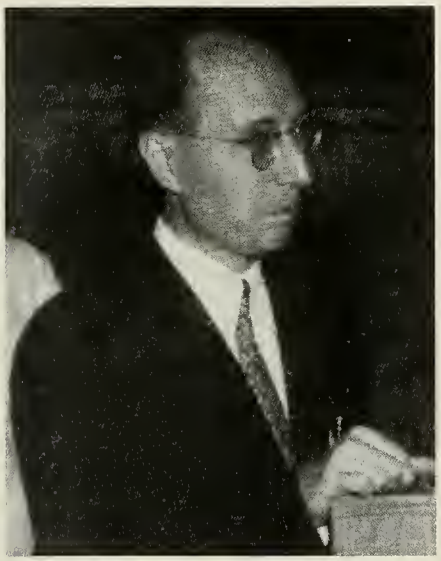
In recognition of these many accomplishments, Cowan, now president of an innovative center for research and graduate education in Santa Fe, N.M., recently received the Enrico Fermi Award, the highest scientific honor awarded by the U.S. Department of Energy. The prize, given annually since 1954, includes a presidential citation, a gold medal and a $100,000 honorarium.

By his own admission, George Cowan was a reluctant scientist. Born in Worcester in 1920, he graduated from Classical High School and enrolled at WPI in 1937. He decided to major in chemistry, he says, because "it was the easiest and most expedient thing to do." His real interest then was economics and he thought for a time he might pursue a career in business.

"I was not terribly happy with science and was trying to make up my mind as to what I wanted to do," he says. "I never really did get focused until I went down to New Jersey and started working with physicists at Princeton."

Cowan's first job after graduation was as a research assistant at Princeton's Palmer Physical Laboratory, where he helped conduct studies with the lab's cyclotron. He worked with Eugene Wigner, the brilliant Hungarian physicist who had emigrated to America in 1930 and who would later win a Nobel Prize; with Robert Wilson, the Berkeley educated Princeton instructor who led the Manhattan Project's cyclotron program; and with Edward Creutz, who would develop the explosive charges that forced pieces of uranium into a critical mass in the first atomic bombs.

A frequent visitor to Princeton at the time was Enrico Fermi, who had escaped



Among the scientists with whom George Cowan worked at Princeton's Palmer Laboratory was the brilliant Hungarian physicist Eugene Wigner.

fascist Italy in 1938 after traveling to Oslo to receive his Nobel Prize in physics. Having already made his mark in science with his theory of beta decay and his discovery of the weak atomic force, Fermi lead the team of Manhattan Project scientists who built the first nuclear reactor.

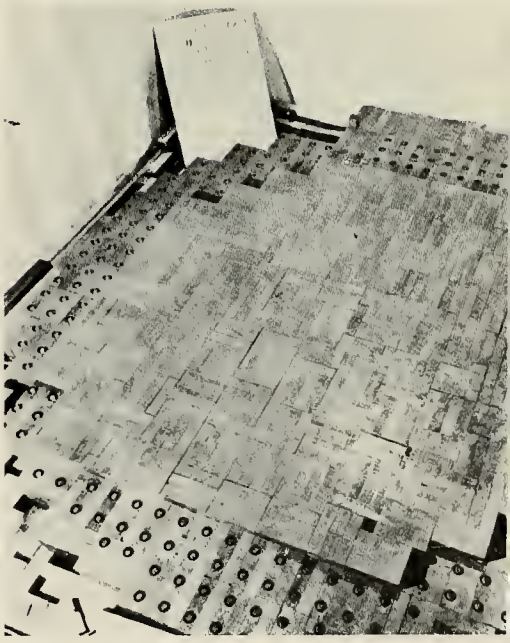
"My colleagues were brilliant and all very prestigious," Cowan recalls, "or they went on to prestigious careers—Richard Feynman was a particularly fascinating example. I thought, 'this is the league I want to be in.'"

During the fall Cowan helped perform some of the fundamental measurements that would show whether or not a sustained nuclear chain reaction was possible. Though the U.S. had not yet entered the war, work was already under way on harnessing the energy of atomic fission to make a new type of weapon—one that could unleash, in a single explosion, the destructive potential of thousands of tons of TNT. To prove that such a weapon was feasible, Fermi and his colleagues at Princeton realized they would first have to achieve a nuclear chain reaction.

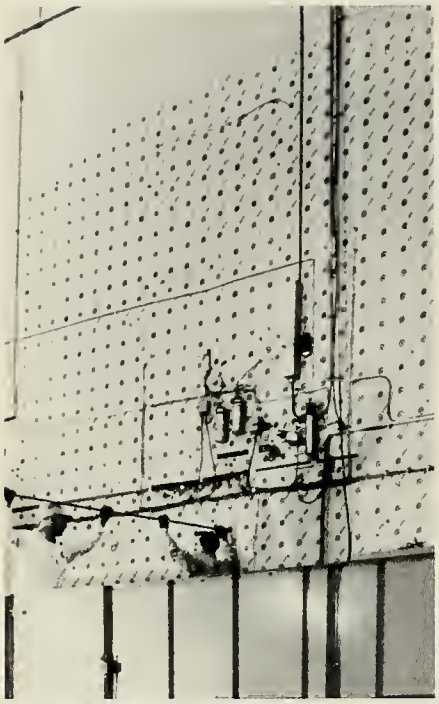
Knowing that the energy released in such a reaction would create extremely high temperatures in a mass of fissioning uranium, Fermi wanted to find out how this heat would affect the ability of uranium atoms to absorb neutrons—if high temperatures degraded this ability, the chain reaction would likely cease soon after it started. "We made measurements at 1,000 degrees Celsius in the cyclotron," Cowan remembers. "Our results were favorable, which cleared the way for the design of the first nuclear reactor."

In December, Japan bombed Pearl Harbor, finally drawing the United States into the war. Work at the cyclotron, which was already running seven days a week, accelerated, and 80- and 90-hour work weeks became the norm. In short order, Cowan was asked to join the newly established Metallurgical Laboratory at the University of Chicago, a code name for the vital first stage of the Manhattan Project—the development of the world's first sustained chain reaction.

"Very quickly, because I knew some chemistry, I was partly detached from the construction group in Chicago and sent around the country to expedite the production of materials necessary for the chain reaction," Cowan says. By that time, it had been decided that the first nuclear reactor



As a scientist with the Metallurgical Laboratory at the University of Chicago, which conducted some of its chemistry research in the building on the left, Cowan helped prepare pure metallic uranium for the world's first successful atomic pile. (right).



The pilot plutonium production reactor at Oak Ridge, Tenn., where Cowan was briefly assigned.

—or pile, as it came to be known—would consist of lumps of pure uranium metal and uranium oxide imbedded in bricks of pure graphite.

Helping speed the production of pure uranium metal was the first task to which Cowan was assigned. In 1942 uranium was used primarily in the production of certain kinds of glasses and ceramics. Westinghouse, which was then experimenting with using uranium in light bulb filaments, was one of the few companies in the world that had produced any of the element in its pure metallic form. Using an electrolytic technique, Westinghouse could make a small quantity of uranium metal each year at a price of about $20 per gram. It would take many thousands of pounds to make the first atomic pile.

While still at Princeton, Cowan traveled to the Westinghouse lab in Bloomfield, N.J., to persuade the company to expand its efforts. "Right away, they signed a contract to scale the thing up and make a few pounds of uranium, which at that time was a tremendous amount," Cowan says. "I couldn't imagine how they were going to do it, but they did it very quickly. I think that was the first time anyone had produced pure uranium metal in any significant quantity."

Cowan also visited Metal Hydrides, a small company in Beverly, Mass., that made a powdered uranium metal—a substance that had one major disadvantage: when exposed to air, it burst into flames. "I remember we tossed one can out onto the lawn and it burned into the ground about a foot deep," Cowan says. "It was the most dangerous stuff you ever saw. We finally learned how to use it, keeping it under an inert gas until we melted it down in an electric induction furnace. Once it was melted down, it wasn't pyrophoric anymore."

Another manufacturer asked to help in the production of uranium metal was Mallinckrodt Inc. in St. Louis. "They had a plant for making ether, and one of the processes we were looking at was extracting uranyl nitrite from uranium ore with ether. It was a great way to purify uranium. I went out to help them get started and spent the hot summer of '42 there."

That fall, Cowan returned briefly to the University of Chicago to work with the reactor group that was shaping 500 tons of graphite and 50 tons of uranium and uranium oxide into the first Chicago pile, or CP-1, inside a squash court under Stagg Field. Cowan helped solve some problems the group had encountered in pressing the uranium into five-pound pellets called pseudospheres, then traveled on to MIT, where the uranium metal itself was being produced. For security purposes, "they called it titanium, which didn't seem to fool anybody," Cowan says. "Titanium is a very light metal, and the stuff we were working with was much heavier than mercury. The students at MIT would say, 'that's very strange titanium.'"

Throughout the fall, the MIT group continued to ship the metal to Chicago as fast as they could produce it. "I was getting phone calls all the time about accelerating production," Cowan remembers. "Then one day there was a sudden call saying, 'you can stop production and come home.' I knew then that the thing had worked."

Back in Chicago, at 3:48 p.m. on Dec. 2, 1942, Enrico Fermi had ordered the last of several control rods (rods made from boron, which absorbs neutrons and prevents a chain reaction from starting) pulled out to a predetermined distance, and the pile went critical. Many would call that moment the greatest scientific achievement of the Manhattan Project.

In 1939 Emilio Segré and Glenn Seaborg used a cyclotron at the University of California at Berkeley to bombard uranium with neutrons. One of the products they created was a new element with atomic number 94, which they named plutonium after the ninth planet in the solar system. In later research it would become apparent that plutonium had a higher fission cross section for slow neutrons than did uranium—in other words, having absorbed a slow neutron, plutonium was much more likely to fission. That made it an attractive material for making atomic bombs.

At the time of the attack on Pearl Harbor, the world's complete supply of plutonium could be seen only with the aid of a microscope. To make a bomb from this element, several pounds would be needed. The easiest way to make plutonium is in a fission reactor. While uranium 235 fissions when it absorbs slow neutrons, U238—by far the most common isotope of uranium—can absorb neutrons and mutate to become plutonium.

Plans were drawn up in 1942 for a mas-

The technical area of Los Alamos National Laboratory in New Mexico as it looked toward the end of the war, shortly before Cowan joined the lab's scientific staff.

The Norsk Hydro plant in Vemork, Norway, where Germany produced heavy water for its atomic bomb project. Worry over Germany's progress helped drive the Manhattan Project.

sive plutonium production operation on the shores of the Columbia River at Hanford, Wash. In the meantime, Du Pont, the contractor chosen to head up the plutonium production and processing efforts, decided to build a pilot reactor at Oak Ridge, Tenn., the site where the huge buildings for separating plutonium and enriching uranium for nuclear weapons were also being built.

For his next assignment, Cowan says he had to quickly become an expert in plutonium chemistry—something very few scientists could then claim to be. He traveled to Oak Ridge, where engineers were having a difficult time getting reliable measurements of the amount of plutonium they were producing.

"I helped solve that problem and returned to Chicago, only to be sent somewhere else," he recalls. "I was always stopping in Chicago to pick up clean shirts and then heading off again."

In another time, many of the problems solved by Cowan and the rest of the Manhattan Project scientists might have seemed insurmountable. But, with the growing threats posed by the Axis powers in Europe and the Japanese forces in the Pacific, and the constant fear that Hitler's scientists were busy developing an atomic bomb of their own, everything seemed possible, Cowan says.

"You never approached any of these problems thinking, 'this is very difficult.' You just did it. What's more, you had the resources to do it," he says. "If someone said they needed this or that, they'd get it—even if it meant a call to the White House.

"For a person in his early 20s, it was a heady kind of power to be able to say to someone who told you that a task would take six months, that they'd have to get it done in a week. If that person knew that not meeting the schedule would mean getting a call from someone in Washington, it would usually turn out that they could do a lot better than they admitted."

Security was another fact of life for everyone involved in the Manhattan Project. To prevent a typical scientist or technician from learning too much about the project, the effort was compartmentalized and the transfer of information from one compartment—or center of activity—to another was limited. Only those with a need to know fully understood the ultimate goal of the Manhattan Project—some popular accounts say even the wives of several top scientists did not know about the atomic bomb until it was dropped on Hiroshima.

Cowan's job frequently allowed him to hop from compartment to compartment and to interact with a wide range of members of the Manhattan Project team—from scientists to bench workers. He soon discovered that many of the compartments were "leaky," he says. "While many people did not officially know the whole story, they would have had to have been deaf, dumb and blind to not realize what was going on."

Despite the long hours, the pressure and the secrecy, Cowan remembers his years in the Manhattan Project fondly. "For young people—and practically everyone who worked on that project was young—the work week was tolerable. We got by on five hours of sleep a night and a six-day work week was normal, but we could take it. I don't think I could ever dream of going back to it, but I could do it then.

"It was an interesting and unusual time. I don't remember it as a time that was unpleasantly spent. It was full of problems to solve and things to do and people who were focused on a common goal, spurred by the overhanging threat that Germany would succeed first."

On Aug. 14, 1945, the world-at-large finally understood what that goal had been. With two of its industrial cities—Hiroshima and Nagasaki—in ruins from the detonation of just two bombs, Japan surrendered, ending six years of global war. As the Manhattan Project wound down, George Cowan worked briefly at Columbia University with John Dunning, who had developed the idea of separating U235 from U238 by gaseous diffusion—a process by which uranium hexafluoride gas is passed through a series of porous barriers. The lighter U235 atoms pass through the barriers somewhat more readily than the U238. In practice it required a massive plant—covering some 43 acres—and thousands of barriers to complete the job.

Cowan worked with Dunning's group on measurements of the absorption of neutrons in a variety of elements as a function of neutron energy. Two members of the group—James Rainwater and Madam C. S. Wu—later became Nobel laureates. In later years he used the training he received in Dunning's lab to measure neutrons made in nuclear explosions. Late in 1945, Cowan moved to New Mexico to join the staff of the Los Alamos National Laboratory—in part, he said, to follow "a pretty girl who would later become my wife."

Los Alamos, a remote mesa in the New Mexico desert that had been the site of a boys school, was chosen in early 1943 as the location for the laboratories and support facilities for the scientists and technicians who designed and assembled the first atomic bombs. The bomb exploded at Trinity Site, about 150 miles to the south of Los Alamos, and the two bombs dropped on Japan were crafted there.

After the war the work at Los Alamos turned to the task of translating the theoretical and experimental accomplishments of the Manhattan Project into a mature nuclear arms program. "We were getting acceleratingly large shipments of plutonium from the production plants at Hanford and were still

learning how to deal with it," Cowan says. "The bombs that ended the war were very much handmade things, and we faced some big problems after those devices were built. We were developing a whole new technology at the time to handle the tons of plutonium destined for new weapons."

No sooner had Cowan begun to focus his energies on some of those problems when he was asked to pack his bags and head for the middle of the Pacific Ocean, where the U.S. was preparing for Operation Crossroads—the first postwar bomb tests. He was asked to help develop techniques to measure the efficiency of the bombs, one of which would explode in the air over Kwajalein Island in the Bikini chain (the Able test) and the other of which would be detonated beneath the island's lagoon (test Baker).

"We collected air samples after the air explosion and sea water samples after the underwater explosion," Cowan recalls. "In order to measure the efficiency of the explosions, which was considered a high priority, I had to separate plutonium from these samples while someone else separated other fission products."

To retrieve the samples, Cowan and the other scientists worked closely with the Air Force. In fact, during the Baker explosion, Cowan was permitted to ride in the Air Force B-17 that directed a flight of instrument-packed drone aircraft circling the site. It was from this aircraft that the now famous photograph of the bomb test (below)—which raised a wedding-cake shaped cloud of water and seafloor debris above the lagoon—was taken.

"The photographer who took that picture was strapped into the open door of the bomber," Cowan says. "When the shock wave reached us we were in too close. We were hit by a force of about nine Gs, which was almost enough to take the wings off the plane. The photographer fell out the door and was hanging by the straps with his camera around his neck. We hauled him in, but we almost lost the picture and the photographer."

After Operation Crossroads, Cowan returned to the United States and enrolled as a graduate student at Carnegie Institute of Technology (now Carnegie-Mellon University). Helen, his newlywed wife, worked for Dean of Graduate Studies "Jake" Warner, with whom Cowan had worked during the war. Warner, who would later became president of Carnegie-Mellon, offered Cowan an instructorship. Also helping to finance Cowan's graduate education was the money he had earned in the Pacific—triple overtime, seven days a week. "I sailed through graduate school—it was another great experience," Cowan says. "I wasn't motivated to be a great scientist, I just wanted to experience every aspect of science that I could sample. I got into a whole new field of chemistry there—gas kinetics."

The mathematics needed to understand the complex behavior of gas molecules—dynamical differential equations—would prove helpful some 30 years later when Cowan helped found an institute dedicated to the study of even more complex systems—living organisms and societies.

With his new Ph.D., Cowan returned to Los Alamos in July 1949 to work as a radiochemist. A month after his return, Roderick Spence, head of radiochemistry at Los Alamos, dropped by and began asking Cowan a series of detailed questions about the status of his new laboratory.

"He practically hung me by my thumbs while I swore that there was no radioactivity in that laboratory," Cowan recalls. "He said, 'OK, we're taking over your lab,' and I said, 'have the Russians shot a bomb?' He looked at me and said, 'how'd you know?' I don't know how I read his mind, but he then took me into the thing. Very rapidly, I became familiar with concepts that I previously knew nothing about."

When the initial samples of debris from that first Soviet bomb test arrived—so quietly and covertly that Norris Bradbury, then the director of Los Alamos, was unaware that they were at the facility—Cowan had to help determine how to prove, first of all, that the material was truly from an atomic bomb blast. For back in Washington, there were many intelligence analysts who were not ready to believe that the Russians were capable of developing a bomb. "We had to prove it 20 different ways before we could win that argument."

The intelligence community had underestimated the ability of the Russians "to put things together," Cowan says. Though they were allies during the war, the United States had worked hard to keep vital information about the development of the atomic bomb out of the hands of the Soviets. But, through a network of spies, the U.S.S.R. learned most of what it needed to know. "Once you know

it can be done and all those questions are solved, the industrial effort is not all that difficult," he notes.

To prove that the debris was from a bomb and not a reactor accident or a fire in a plant with radioactive material, it was necessary to show that all the radioactive species in the debris were formed at exactly the same moment. "All these materials have different half-lives," Cowan notes. "So, if you make some careful measurements of the ratios of all these fission products to one another and then extrapolate them back in time and find they have a convergent time of origin, you can demonstrate that there was an explosion.

"Depending on how soon after the event the sample was collected, and how many products you measure—and how precisely, you can date the event and reconstruct the history of the process that made those fission products."

In the years after that first Russian test, Cowan became one of the world's leading authorities on nuclear weapons diagnostics, and many of the techniques he helped develop remain the state of the art today. As associate leader of the Test Division at Los Alamos (a post he assumed in 1957), he helped supervise weapons tests in Nevada, Eniwetok, the Christmas Islands and a number of other sites.

"The Test Division was responsible for transporting a weapon to a test site, testing it, and making all the diagnostic measurements necessary to tell the people who had designed it what it had done—whether it had conformed to their calculations," Cowan says.

"As with the analysis of the Russian tests, you had to have enormous redundancy in the data, because if you told the designers anything that didn't conform to their expectations, you had to prove it—and prove it in more than one way. Otherwise, they'd tell you you had made a mistake, which was always possible."

Accurately measuring the outcome of a fission weapon test required painstaking attention to detail in the collection and analysis of debris samples. But that task would pale in comparison to the difficulty of diagnosing the blast of a thermonuclear weapon, as Cowan would discover when the first hydrogen bombs were tested in the early 1950s.

"There was a whole new set of problems," he says. "When you fuse two deuterium atoms, your products are helium and neutrons, neither of which can be directly measured in the debris cloud. So, unlike testing a fission bomb where there are many products that enable you to get redundant measurements of what happened, with a fusion device there is, in principle, nothing to measure."

CARY HERZ

An informal meeting in the courtyard of the Santa Fe Institute's adobe headquarters. (Left to right) Bela Julesz of Rutgers University, Seth Lloyd of California Institute of Technology, Cowan, and Philip Anderson of Princeton University.

With no radioactive products to collect, Cowan helped devise tests using exotic materials that, when bombarded by the energetic neutrons produced by a thermonuclear blast, mutated into characteristic radioactive isotopes (called secondary products) that can be measured. The manner in which the materials change into secondary products is a reliable indicator of how many neutrons are produced in a blast. The number of neutrons, in turn, tells you with a great deal of accuracy how efficient the weapon was.

Materials used in the construction of the bomb—or put there purposely to help in the diagnostic tests—can also be measured. For example, thermonuclear weapons use fission bombs to create the tremendous heat and pressure necessary to fuse deuterium. When irradiated with the fast neutrons from a hydrogen bomb explosion, the uranium 238 in a fission bomb can be converted to another uranium isotope—U237.

"If you detect U237," Cowan says, "you know, first of all, that there were fast neutrons produced in the thermonuclear reaction. If you combine this result with a few other measurements, you can say how successful that reaction was. It turns out that once you start looking at it, there are indeed highly redundant measurements you can make to demonstrate to someone who isn't prepared to believe your data that you are, in fact, right."

The techniques Cowan developed to analyze the results of nuclear weapons tests—in particular those of thermonuclear devices—have won him numerous awards and honors over the years. In 1965, President Lyndon B. Johnson and the Atomic Energy Commission presented him with the E.O. Lawrence Award. Named for the inventor of the cyclotron and one of the leading scientists in the Manhattan Project, the award is given each year to five scientists under the age of 45 working in the basic sciences.

The New Mexico Academy of Science honored him with its Distinguished Scientist Award in 1977 and Cowan has been named a fellow of the American Physical Society and the American Association for the Advancement of Science. He has been a member of the White House Science Council and the Science Advisory Committee of the Air Force Tactical Air Command; a consultant to the Defense Intelligence Agency; chairman of the Division of Nuclear Chemistry and Technology of the American Chemical Society; and a member of the Geological Site Selection and Waste Isolation panels of the National Research Council.

WPI honored Cowan in 1983 with its Robert H. Goddard Alumni Award for Professional Achievement. Interestingly, Goddard, a 1908 WPI graduate, also spent the seminal years of his scientific career in New Mexico. He conducted many of his later rocket tests in a remote location in the desert near Roswell, about 200 miles southeast of Los Alamos.

Cowan's work on nuclear weapons diag-

nostics was one of several accomplishments listed in the citation for his Enrico Fermi Award, announced by the Department of Energy in late 1990. "That's where I made what reputation I have—inventing a lot of those techniques and demonstrating that they work," Cowan says. "That's what has earned me all sorts of things that I now have hanging on the wall at home."

In 1971 Cowan became leader of Los Alamos' Chemistry and Nuclear Chemistry Division, a post he would hold until becoming associate director for research for the national laboratory in 1979. During that time, he made important contributions to the understanding of two unusual phenomena—a natural nuclear reactor in Africa and solar neutrinos.

Oklo, the site in central Africa of a uranium ore deposit that apparently had once gone critical, was discovered by French researchers in 1972. "They said it was a fission reactor," Cowan recalls, "but I knew that was impossible—at least in modern terms. You can't assemble a reactor today with uranium ore. But just as Professor Masius hadn't known about how many neutrons are produced when uranium fissions, I didn't know then how old the ore was."

Cowan visited the French scientists and persuaded them to give Los Alamos a sample of the ore to analyze. They discovered that the deposit dated back two billion years. "The half-life of U235 is short enough," Cowan says, "so that if you extrapolate back that far, you find that instead of making up 7/10 of a percent of the ore, as it does today, it made up 3 1/4 percent, which was just enough to allow it to go critical."

Sitting in a geologically stable area, virtually free of plate tectonic or volcanic activity that might have dispersed it, the ore has remained intact for nearly half the age of the Earth. What was more significant, Cowan realized, was the fact that the ore had not been dissolved by ground water. "This was of immediate interest to our nuclear waste storage people," he says. "In some forms—including uraninite, the type of ore found at Oklo—uranium is extremely stable and insoluble. Even the fission products in the ore were not dispersed."

Unfortunately, Cowan says, by the time the Oklo site was discovered, the U.S. had already decided to store its waste in the form of a vitreous glass. "We tried to show them how successful nature had been—that the waste should look more like that ore. After all, nature has not demonstrated the efficacy of the other solution over the course of nearly two billion years. But we never won that argument."

Ore deposits also figure in a unique approach Cowan devised for tracking the activity of solar neutrinos—subatomic particles produced by thermonuclear reactions in the sun. The intensity of the stream of neutrinos that emanates from the sun provides a highly accurate indicator of the temperature of the interior of this star. Unfortunately, it is extremely difficult to detect neutrinos, which have no mass and no electrical charge. Elaborate underground chambers, filled with millions of gallons of a detector, have been employed with important but inconclusive results.

In Cowan's scheme, molybdenum ore buried under the Earth's surface serves as a neutrino detector. By calculating the probability that a given neutrino will interact with a molybdenum atom, and then analyzing a quantity of ore for technetium (a metallic element normally obtained only by bombarding molybdenum with neutrons or as a fission product of uranium) to see how many molybdenum atoms have actually undergone such a reaction, one can determine the intensity of the neutrino stream.

"But the problems of doing this are almost insurmountable," Cowan says. "You have to find a way to extract a handful of atoms from thousands of tons of ore. In fact, the quantities of material you are searching for are so small you have to develop new analytical techniques to measure them. It's a very difficult problem that has only partially been solved, even now."

In 1981 Cowan was named a senior fellow at Los Alamos, a post that gave him the freedom to think about some of the issues and ideas in science that had come to intrigue him over the years. One of those issues was the difficulty of conducting truly interdisciplinary science.

"At Los Alamos I had theoretical physicists, experimental physicists, chemists and life scientists reporting to me," he says. "Each was an expert in his field and each was intent on staying away from the other fields—partly because learning the jargon of another field of science would be like learning a new language. When the scientists did work with one another, though, the results were always very good."

In fact, in the laboratories under his direction Cowan observed high-quality work in one of the most successful and exciting interdisciplinary collaborations in modern science—molecular biology, "a magic fusion" of physics, chemistry and biology. He became convinced that with the right approach, similar collaborations could be brokered in other fields.

"When people talk about interdisciplinary collaboration, they frequently mean setting up a center on a university campus and hiring scientists from different fields to work there," he says. "But, while it's relatively easy to hire a good bunch of people, it's very difficult to get them to work together. That takes a lot more thought."

Toward that end, Cowan and a few other Los Alamos senior fellows founded the Santa Fe Institute in 1984 in a roomy adobe building that once served as a convent for the nuns who ran a parochial school. The school still operates across the street from the institute, but today lay people teach the students. In the chapel where the nuns attended services, conferences are now held, and in rooms where the sisters once slept, scientists create complex models on powerful computer workstations.

Once the institute was proposed, other

The "Mike shot," as the explosion of the world's first thermonuclear device was called, erupts at Eniwetok in October 1952. Cowan helped solve the immense problems associated with measuring the efficiency of hydrogen bombs, work that has earned him many honors over the years.

eminent scientists became involved, including Murray Gell-Mann, Robert A. Millikan Professor of Theoretical Physics at California Institute of Technology, David Pines, professor of physics at the University of Illinois, and Kenneth Arrow, a Nobel laureate and professor of economics at Stanford University. Today, the rosters of the institute's faculty and science board read like a "Who's Who" in American science.

"Establishing a true interdisciplinary research center, like the Santa Fe Institute, is a problem of sociology," says Cowan, who, having retired from Los Alamos in 1988, now serves the institute full time as president (he will retire from that post later this year). "You have to choose people who will talk to each other. They have to be very good and very secure, otherwise one person starts to dominate the rest. You wind up with strong-minded people who have a hard time getting along, until they realize that they have so much to offer each other. That's the secret."

The primary goal of the institute, Cowan says, is to better understand complex systems, which can be defined as systems that are able to remember and profit from past experience. Examples of such systems range from proteins, which have a molecular memory enabling them to fold themselves into one or more complex shapes in response to changes in their environment, to human society and culture. Recent conferences at the institute have covered such diverse topics as the evolution of technology and the organization of prehistoric societies in the southwestern region of the United States.

A major focus of research and graduate education at the institute is "shaking up the world of economics," Cowan says. "We're trying to add nonlinear terms to this science. In neoclassical economics, people like to prove theorems. And, to prove theorems, you have to linearize the science. Our approach bothers many people because we say that economics is inherently nonlinear, and it's characteristic of nonlinear systems that there are no singular solutions; there are multiple solutions that are all good enough, in the sense that they persist. Trying to talk about the best possible solution in such a system is a waste of time."

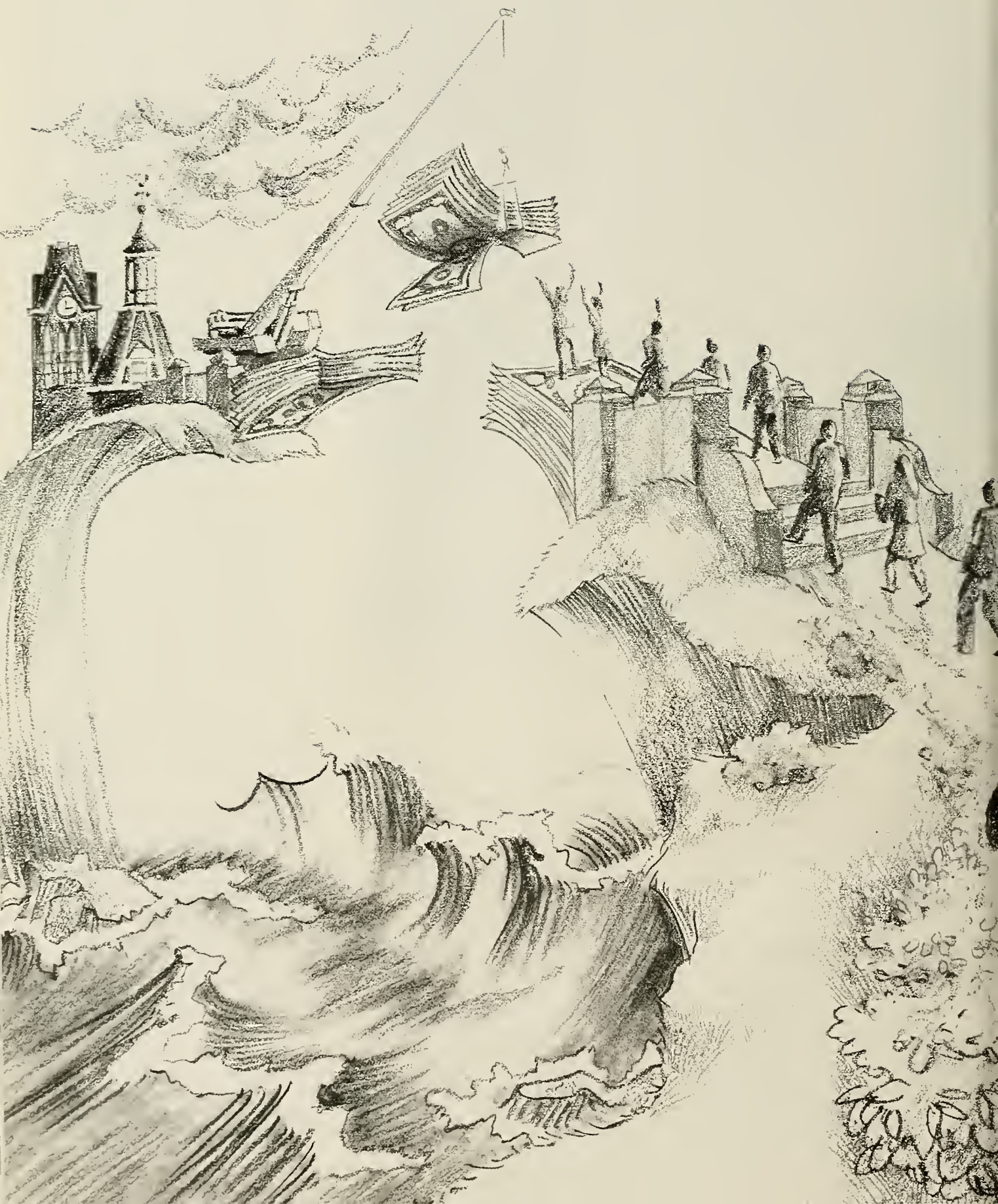
In part, what makes economics (like all aspects of human society) nonlinear is that the information upon which we base economic decisions is never perfect and the way we process that information depends heavily on our past experiences. This process—called a feedback loop—is a characteristic of all complex, adaptive systems.

"This approach to economics offends some people and intrigues others," Cowan says. "Nonetheless, we're having an effect; we're making waves quietly, I hope. People are calling up and asking to join us. We have to choose from among many more than we can bring in."

To better understand the behavior of the global economy, researchers at the institute are developing what are called adaptive computational techniques. These are computer models that mimic elements of the worldwide economic system. The institute has helped establish a center at the University of Michigan under the direction of John Holland, professor of computer science and engineering, where some of the university's brightest computer and social scientists work on these models. Another allied center has been set up at the University of Arizona under Peter Carruthers, head of the physics department.

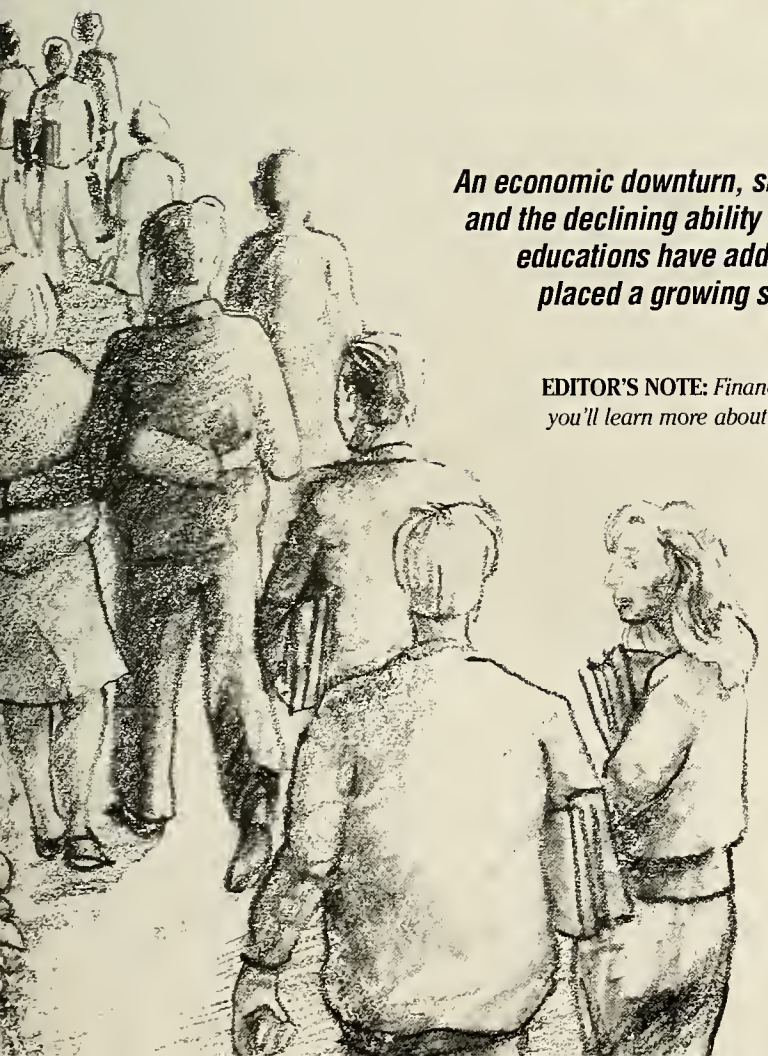
"Our goal," Cowan says, "is to produce one seminal paper demonstrating that by introducing some of these ideas to economics it is possible, in a scholarly way, to describe a dynamic process that corresponds more to the way the real world operates than do the conclusions of more conventional neoclassical economics."

It is a goal that brings Cowan's own life full circle. The student who once toyed with the notion of becoming an economist, today stands at the threshold of a new era in that field. The once reluctant scientist is now bringing nearly five decades of experience as a renowned researcher to bear on problems that may well prove more complex and challenging than those that tested the scientists of the Manhattan Project. And, the young chemist who once aspired to join the league of the prestigious men of science, has now taken his well-deserved place among their ranks.



THE FINANCIAL AID GAP

By Michael Dorsey



An economic downturn, shrinking federal student aid funds, and the declining ability of families to pay for their children's educations have added to WPI's financial aid burden and placed a growing strain on its budget.

EDITOR'S NOTE: *Financial aid has a technical side and a human side. In this story you'll learn more about the former. The brief profiles of alumni who received aid while at WPI (written by Ruth Trask) and the stories of a few current aid recipients that begin on page 16 illustrate the latter.*

Economists may debate when—and if—it happened, but most now agree that the economic boom of the 1980s has become the recession of the early 1990s. Across the country the signs are legion. The headlines in the business pages chronicle a seemingly endless stream of layoffs, fore-closures, business closings and bank failures. The message seems clear: the good times are over, and an era of belt tightening has begun.

The arrival of the economic downturn comes as no news to many of the nation's

ILLUSTRATION BY PAUL METCALF

PORTRAITS BY RICHARD GIEDD

Christopher T. Terpo '44

Worcester, Mass.

Owner and president, C. T. Terpo Company

Student Years: *B.S. in mechanical engineering, Glee Club, Professional Society, Sigma Phi Epsilon.*

Alumni Years: *Worcester chapter representative to WPI Alumni Council, 1956 to 1960, Tech Old Timers.*

After graduation Terpo worked on design and maintenance programs for Shell Oil Company and in the metallurgy laboratory at Wyman-Gordon Company before joining Norton Company's sales engineering department, working on the introduction of new products and troubleshooting. In 1950 he started his own business, C. T. Terpo Company, a distributor and representative for industrial tooling and guaging.

He has been active in a number of professional engineering societies and is a member of the Masons, the Shriners and the Grotto. He often takes part in local amateur theatricals, participates in church and YMCA activities, and enjoys tennis, badminton and skiing.

"I was the recipient of a yearly tuition scholarship set up between WPI and a local manufacturing company, where my father had worked as a machine operator," Terpo says. "Even though I had excellent high school credentials, attending WPI without aid would simply have been a dream. Whatever success I may have had, professionally and socially, I attribute to my years at WPI—unequivocally."

colleges and universities. Over the past year, hundreds of campuses—public and private—have seen their own financial fortunes take a decided turn for the worse. Seen together, their stories form a troubling tableau:

- Last October Brandeis University instituted a hiring freeze to help combat a projected $2 million budget deficit, a shortfall that could grow to $4 million in the next budget year.
- Bryn Mawr College, having eliminated jobs through attrition, sold some of its property, and reduced operating costs, recently began a five-year plan to eliminate four graduate programs.
- To deal with its budget problems, Columbia University closed its linguistics, geography and library science programs. Washington University in St. Louis closed its dental school and announced plans to cut its sociology department, as well.
- Having cut its budget $13.4 million during the last four years, Cornell University must implement an additional $10 million in cuts to balance its budget and fund priority activities. The university has launched a $1.25 billion capital campaign designed, chiefly, to reinforce existing programs and activities.
- Hoping to hold the line on tuition increases, Dartmouth College has cut its operating budget by 1.8 percent and eliminated 55 positions, mostly through attrition.
- To save nearly $3.5 million, Franklin and Marshall College cut 15 positions, sold its bookstore, cut back on publications, closed its print shop, and refinanced a bond issue.
- Facing a sizable deficit, Harvard University has asked all of its departments to cut their budgets 6 percent, a move the university admitted might affect services to students and faculty.
- Financially strapped Northeastern University announced in January that it would lay off 175 administrators and staff—about 10 percent of employees in these areas. The layoffs will be accompanied by retirements and a hiring freeze.
- To deal with a $3.5 million deficit, Oberlin College has announced plans to eliminate 26 positions and cut back on operations, equipment and maintenance.
- Stanford University, an institution with a $2 billion endowment and a $1.1 billion fund-raising drive well under way, announced last fall it was cutting its budget 13 percent, laying off more than 100 nonteaching employees, and reorganizing its administration to make it more efficient.
- The victim of a recession-riddled state budget, the University of Massachusetts last fall struggled to achieve a mandated $16.6 million budget cut.

As they have at these institutions, budget shortfalls have visited WPI in recent months. This year a cutback in state financial aid funds and increased financial aid costs produced a $500,000 gap (about 1 percent of the unrestricted operating budget) that was eliminated through reductions in auxiliary and administrative expenses. The Institute has been working to cut back the expense budget originally proposed for the 1991-92 academic year by $2.5 million. Annual cutbacks on the order of $2 million each are possible in the years beyond that.

A number of factors have helped set the stage for this era of tough budget planning at WPI and other U.S. colleges. A shrinking pool of college-bound students has made colleges work harder for, in some cases, smaller enrollments. Federal support for higher education has not kept pace with inflation, let alone with the rising cost of a college education (which has been growing by about 1.5 to 2 percent faster than the rate of inflation for the past several years). And, of course, there is the economic downturn, which has left corporations, foundations, alumni and parents with less money to devote to higher education.

At WPI these factors have intersected at one crucial budget element—student financial aid. To guarantee access to qualified students—and to compete with other high-quality colleges of engineering and science in the face of a shrinking applicant pool, the Institute has bolstered its commitment to meeting the financial needs of its students over the past several years. At the same time, the turn toward recession and shrinking federal financial aid outlays have left the families of WPI students increasingly unable to meet the cost of a WPI education.

The result is a growing gap between the cost of attending WPI and the ability of students to pay that cost. WPI has attempted to fill the gap—to the extent that it can—with Institute funds, but the cost of doing so grows substantially each year. In fact, the college has arrived at the point where the added financial aid burden that accompanies an increase in tuition all but consumes the additional income the college might have realized from the increase.

"Clearly," notes WPI President Jon C. Strauss, "we've reached a crossroads, one that all private colleges and universities will approach soon enough. If society values what private higher education offers its citizens, it will have to act to help keep this system viable. But in the meantime, the solution will be up to us."

The journey to this crossroads began in the 1980s, a decade that will be remembered in the corridors of academia as a time of increased spending. During the 1970s, a decade of double-digit inflation and skyrocketing energy costs, colleges were forced to roll back their spending. Building maintenance was deferred, teaching laboratories were allowed to become out of date, and the rate of increase in faculty and staff compensation was curtailed. As the economy became more robust in the 1980s, colleges increased their budgets to make up lost ground.

The decade was also a time of heightened competition. Starting in the early 1980s, the pool of college-bound 18-year-olds began to shrink. The drop-off has been especially steep in the Northeast. In New England alone, the number of 18-year-olds will decline by nearly 18,000 students—13 percent—between now and 1994, adding to a 16 percent drop since 1982. As this trend emerged, colleges and universities found themselves vying for a shrinking reservoir of prospective freshmen. The competition has been particularly keen among technological universities, like WPI, since student interest in engineering and science has also dropped 40 percent since 1986.

Since most colleges derive a significant portion of their operating revenues from tuition income, a decline in enrollment can translate directly into a budget shortfall. Therefore, to maintain enrollments and balance their budgets, many colleges strove during the latter half of the 1980s to enhance their attractiveness to potential students. For most colleges, attractiveness is a function of quality—or at least the quality that prospective applicants ascribe to them.

For generations WPI has been recognized for the high quality of its undergraduate educational program. That quality was enhanced in the early 1970s with the creation of the WPI Plan, the Institute's innovative, project-oriented approach to teaching science, engineering and management. The Plan helped expand the Institute's reputation and recognition in the United States and around the world.

To build on that reputation, WPI increased its commitment to education during the 1980s by expanding its faculty, which helped meet the demands of a faculty-intensive project program and increased the college's involvement in scholarly research and graduate education—pursuits that can increase the relevance and excitement of undergraduate education. Other moves aimed at boosting quality included improvements in laboratories for undergraduate

An Update: WPI Holds the Line on Tuition

Much of the analysis in this article is based on the assumption that the Institute would increase its tuition and fees by 6 percent for the 1991-92 academic year, a proposal under consideration when the article was written. Recently, however, the WPI Board of Trustees decided to take a bold step aimed at bringing WPI's cost better in line with the ability of the families of its students to pay.

Meeting in Boston on Feb. 17, the trustees voted not to raise tuition and fees for the 1991-92 academic year and to hold room and board charges at current levels. Undergraduates will pay $14,125 in tuition and fees to attend the Institute next year, the amount they paid this year. The total estimated annual cost for a typical resident student will remain at $20,045.

"We've reached a point," board chairman M Howard Jacobson said, "where tuitions are nearly out of reach for the average family. By holding the line on tuition this year, we hope to enable family income to catch up with our costs."

In recommending this action, WPI President Jon C. Strauss emphasized its long-term, strategic importance. "The Institute's enrollment is at an all-time high," he said, "and we're setting a new record of quality with our incoming freshmen. This is not a decision born of crises, but rather a reasoned step aimed at positioning this institution for the future."

With no increase in tuition and fees income, the Institute will face additional budget reductions—above and beyond the $2.5 million it has already effected in anticipation of a 6 percent tuition increase, Strauss said. "The trustees realize that this decision will cause a strain on the Institute, but the benefits to be realized—by the families of our students and by the Institute itself over the long term—more than outweigh those costs."

—Michael Dorsey

Lee S. Tuomenoksa '52
Murray Hill, N.J.

Retired vice president, Product Realization Planning and Engineering, AT&T Bell Laboratories

Student Years: *B.S. in electrical engineering, Tau Beta Pi, Sigma Xi, Eta Kappa Nu, Theta Chi, Professional Society, Camera Club, Rifle Club.*

Alumni Years: *master's degree, MIT, additional graduate work, Columbia University, alumni admissions volunteer, 1980.*

Tuomenoksa, a fellow of IEEE, held a number of posts during his long career at Bell Labs, including director of the EES Switching System Laboratory and director of the Digital Terminal Lab.

When he became a vice president in 1981, this native of Finland said, "To come to America not knowing any English and with only $20 in my pocket...and now I'm a vice president at Bell Labs—I'm flabbergasted!"

He earned part of his freshman tuition during a six-month stint at Morgan Construction Co. in Worcester. "However, for the next three years I received tuition directly from the college," he says, adding that financial aid made a world of difference to his future.

"My father was the minister of a small church in Worcester with few funds to help me with my schooling," he says. "Financial aid meant everything to me. It meant that I could receive an excellent education and look forward to an engineering career."

Getting Through It—Together

PHOTOS BY JANET WOODCOCK

Financial aid, provided by WPI and by various state and federal programs, has made it possible for the Daly family of Stoneham, Mass., to have three children enrolled at WPI at the same time. Brian will graduate this May with a degree in civil engineering. Following in their brother's footsteps, sisters Susan (left) and Karen, both freshmen, are also studying civil engineering.

Coming up with the cash to cover four years of tuition, housing, food, fees and phone bills (not to mention the cost of clothing, entertainment and trips home) turns the families of many WPI students into world-class budget jugglers. What they quickly learn is that even with loans, scholarships and summer jobs, it takes a lot of teamwork to produce an Engineer.

"The entire Financial Aid Office staff works closely with a significant number of WPI families to sort through the anxieties, complexities and sacrifices that go along with financing a WPI education," says Michael J. Curley, director of financial aid, who notes that some 1,900 students—more than 70 percent of WPI's 2,707 undergraduates—were receiving some form of financial aid as of last September.

Daniel Walsh, Amy Shoemaker, Bryant O'Hara, and siblings Brian, Karen and Susan Daly form a small cross section of this important segment of WPI's student body. Together their stories say much about the young men and women whose WPI educations have been made possible—at least in part—by financial aid.

In my family, we believe we're all in college together, and we're going to get through it in whatever way we can," says Daniel Walsh '93, a mechanical engineering major with aerospace interests from Fall River, Mass.

Thanks to his fine high school record, Walsh could have attended the University of Massachusetts virtually tuition free, but he wanted to go to WPI. "WPI's small campus appealed to me," he says. "I had a gut feeling that I would like living and studying there for four years. My parents have been generous enough to make the sacrifices it has taken to send me here, especially recognizing that my older brother would be a senior at Colby College while I was a freshman at WPI."

Walsh says his parents (his father is a firefighter and his mother is a special education teacher) have done everything they can to help their sons get their college degrees.

Walsh's financial aid package includes a WPI Scholarship, a Gilbert Matching Grant, and a Stafford Guaranteed Student Loan. He also has scholarships from his high school and from the Elks National Fund. To pay some of his expenses, Walsh worked one summer filling and fixing tanks for a fuel supply company. Last summer he rose before dawn to work as a garbage collector for the Fall River Department of Public Works.

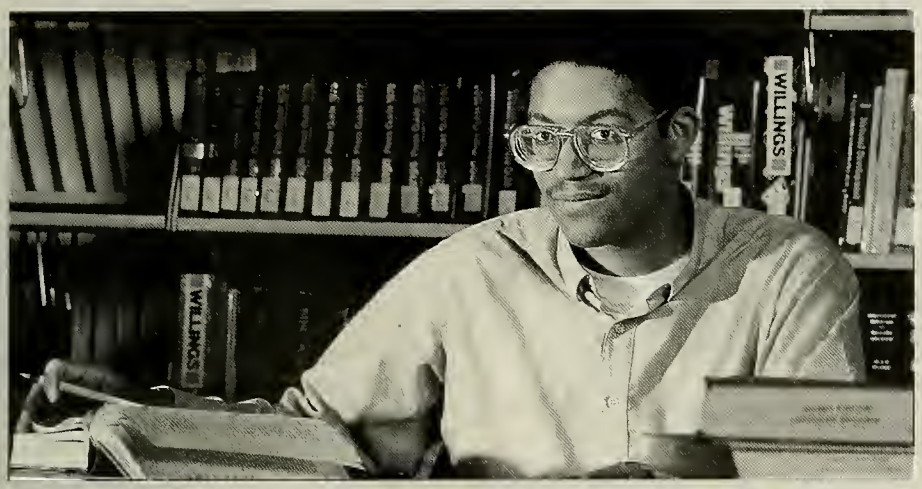
Neither my husband nor I went to college," says Patricia Shoemaker, mother of Amy Shoemaker '92. "We would do anything to enable our daughters to get an education." Larry Shoemaker works as a welder at the Ford Motor Co. plant in Sandusky, Ohio; Patricia is a surgical nurse. Amy's sisters Heidi and Julie attend the University of Toledo. "We're all making a lot of compromises to keep the three of us in school," says Amy.

"I didn't think we could ever afford to send Amy to WPI," Patricia Shoemaker says. "I was impressed by the aid she got." Amy's education is being financed by a WPI College Scholarship, a Supplemental Educational Opportunity Grant, a Pell Grant, a Stafford Guaranteed Student Loan, and a four-year scholarship from the United Auto Workers. Her active schedule (she is captain of the women's volleyball team) includes a 10-hour-a-week work-study job in the Financial Aid Office.

Amy has worked summers in a supermarket and at a nearby amusement park since she entered high school. Last summer she painted curbs, cleared fallen branches and helped out in the water department for the Bellevue Department of Public Works. She also works part time in her hometown public library.

"Amy's an independent person who insists on paying what she can. She doesn't like to take money," her mother says. "She's doing what she wants to do—getting a good education and living away from home. For her, WPI is worth the sacrifices she's had to make."

Bryant O'Hara '92 has always had his sights set on the future. A mechanical engineering major with aerospace interests, he recently decided to combine his interests in engineering and literature by completing a second major in the humanities. "If I could choose a perfect life, I'd work



Bryant O'Hara '92 is combining interests in technology and writing with a dual major in mechanical engineering and the humanities. Financial aid from a number of sources is helping to make his WPI education possible.

as an aerospace engineer and write science fiction on the side."

O'Hara was born in California, where his father, an electrical engineer in the Marine Corps, was stationed. He and his younger brother, Gregory, have lived much of their lives in Albany and Decatur, Ga. Their parents are divorced and they currently live with their mother, Nollie, a micrographics technician who recently retired due to illness.

"My parents taught us that it's not enough to go through life just trying to survive—they wanted us to thrive," O'Hara says. "They told us, 'Do whatever you want with your lives—just do something.'"

Bryant found out about WPI by logging onto a computer search program at his high school. He researched the school and visited the campus for five days. He also applied to Georgia Tech and Tuskegee University and was offered a four-year scholarship to Florida A&M. He says WPI's strong humanities component was a factor in his decision to attend the Institute.

His education is being financed by a WPI College Scholarship, a David Lanier Thompson Memorial Scholarship, a Supplemental Educational Opportunity Grant, a Pell Grant, a Perkins National Direct Student Loan and a Stafford Guaranteed Student Loan. He spends his summers working in Worcester. For the past two years he has driven a forklift truck for Norton Company; last summer he worked for WPI's Plant Services Division. During the academic year he is a work-study student.

"I've been very comfortable at WPI," he says. "I have a lot of friends and I've gotten involved in campus life. I believe WPI is the right school for me, and I appreciate the individuals and groups who have supported me in my quest for an education."

Amy Shoemaker '92 at her work-study job.

Those who think coming up with the funds to finance the education of one WPI undergraduate is a challenge, should take lessons from the Daly family of Stoneham, Mass. Three of the four Daly children are studying civil engineering at the Institute. Brian is a senior and twins Karen and Susan are freshmen.

The Dalys—William, who teaches industrial arts at Stoneham Middle School, and Brenda, a certified teacher who works part time as a tutor at New England Memorial Hospital—are solidly behind their kids. "Brian got accepted to the University of Lowell and to UMass and could have graduated from either of those public colleges loan-free, but he wanted to go to WPI," Brenda says. "A few engineers we know told us a WPI degree would be worth more in the business world, so we agreed to do whatever we could to help him get that education." Three years later they stood by that commitment when their daughters put WPI at the top of their lists.

Active in sports and student life at Stoneham High School, Brian, Karen and Susan wanted to continue those activities in college. Because they believed they could not work and meet their on-campus commitments, each sought a financial aid package with no work-study component. Their packages include WPI Scholarships and Gilbert Matching Grants. Karen and Susan have Perkins National Direct Student Loans and Stafford Guaranteed Student Loans; Brian has a Massachusetts State Scholarship and a WPI Student Loan from the John C. Ward Fund.

Brian has earned extra money working in the construction industry during breaks. Last summer he was hired as a draftsman by Metcalf & Eddy, an engineering company in Wakefield, Mass. He eventually moved into the company's engineering division. Susan and Karen, who worked as waitresses throughout high school, return to that job when WPI is not in session.

"My husband and I believe students have obligations to their schools that go beyond getting good grades," says Brenda Daly, and her children have taken that philosophy to heart. Brian, who has lettered in soccer, swimming and track, won two awards given annually to outstanding junior student athletes.

He has been a member of the Athletic Council and is now treasurer of the WPI Chapter of the American Society of Civil Engineers. He is a member of Chi Epsilon, the civil engineering honor society, and Skull, WPI's senior honor society. He plans to attend graduate school to study environmental engineering after graduating in May.

Following in their brother's footsteps, Karen and Susan have earned letters in cross country and are members of the swim and track teams. "We've been very honest with our children about the kind of teamwork it takes for them to go to WPI," says Brenda Daly. "They've always known what they were getting into, and what it would take for all of us to get them through college."

—Bonnie Gelbwasser

David P. Norton '62

Lexington, Mass.

President,
Nolan, Norton & Company Inc.

Student Years: *B.S. in electrical engineering, lacrosse, Varsity Club, Newspeak, Phi Kappa Theta.*

Alumni Years: *M.S., Florida Institute of Technology, M.B.A., Florida State University, D.B.A., Harvard Business School, Robert H. Goddard Alumni Award for Outstanding Professional Achievement, 1987, WPI trustee, 1990 to present, President's Advisory Council, Poly Club.*

Norton's foresight, ingenuity, and dedication to excellence have propelled him to an extraordinary professional career. In 1974 he and a partner founded Nolan and Norton, a company specializing in information technology, planning and management. The outstanding success of the firm led to a merger with Peat Marwick Main & Co. (now KMPG Peat Marwick), which has gained new prestige for Nolan and Norton as a major division of the world's largest accounting and management consulting firm.

"My education at WPI was a team affair," Norton says. "I received the education while my parents made the many sacrifices to provide the financial resources. WPI was a member of that team as well, providing financial support at crucial times. Looking back, I appreciate how my education would not have been within my reach had it not been for the support of WPI alumni."

teaching and project work, a significant expansion of the overseas project center program, and a major investment in new computer equipment and facilities—including the construction of a $10 million information sciences building, the George F. Fuller Laboratories. The four-year *Campaign for Excellence*, which concluded on Nov. 11, 1990, having raised $63.7 million—more than 21 percent over its target, helped the Institute achieve those goals. But despite the success of this fund-raising drive, much of the price of building upon WPI's excellence has been funded by tuition income. In fact, to meet rising costs the college raised its tuition and fees from $5,938 to $14,125—138 percent—in the decade between the 1981-82 and 1990-91 academic years.

If WPI's track record in attracting and enrolling new students is a measure of the success of those efforts, then the investment in quality has paid off handsomely. While many of its peers have watched their applications and freshman classes shrink in recent years, WPI has maintained its applicant pool and freshman enrollments at or above its targets.

Last fall the college enrolled a freshman class of 733, bringing the undergraduate student body to 2,707. So far this year applications are running above last year's levels. Unfortunately, the enhanced competition has forced WPI to admit a higher percentage of its qualified applicants, though the quality of the entering classes—as measured by SAT scores, number of students in the top fifth of their class, and so on—has remained high. The college has also made a concerted effort to cast its admissions net more widely than in past years, reaching potential applicants across the country and around the world.

"WPI is the only institution of technological higher education in the East that has been able to maintain its applicant pool, its enrollment and its quality," notes Strauss. "But this success has come at a cost."

Part of that cost is the increasing price the Institute has paid to enroll students who can not afford to pay the total bill for attending WPI. Just as colleges competed on the basis of quality during the 1980s, they also have used financial aid as a tool to attract students and to help assure that the students who apply actually enroll. To make its own financial aid offerings competitive with those of other private technological colleges, WPI in 1986 began a multi-year plan to phase in a full-need financial aid policy for all of its undergraduate students. The policy, notes Strauss, was designed to assure that any student qualified to attend WPI would be able to do so, regardless of his or her ability to pay WPI's costs. As the economic boom of the 1980s drew to a close, that policy would prove an increasingly expensive proposition.

The concept of financial aid has changed through the years as society's views on access to higher education have evolved, notes Robert G. Voss, WPI's executive director of admissions and financial aid. "In the first 150 years of higher education in this country, colleges were the haunt of the rich. The Morrill Land Grant Act of 1862 was the first major effort to democratize education and allow greater access. Society then decided that it was to its benefit to foster even wider access to higher education, and financial aid based on need came into play.

"After World War II, as America realized that it needed an educated work force, financial aid became a leveler. With the passage of the GI Bill, it became part of the government's mission to make higher education accessible to large segments of the population."

In more recent years, some private colleges, seeking to enroll more diverse student bodies, further expanded their commitment to making their programs available to a broad range of students with the concept of need-blind admissions. Colleges with this policy divorce the admissions process from financial aid considerations, admitting students without first examining their financial requirements. The colleges then attempt to meet all or a portion of an admitted student's need with financial aid. WPI has long adhered to such a policy.

When a WPI student applies for financial assistance, he or she fills out the standard Financial Aid Form, which is processed—along with forms submitted by college students from all over the country—by the College Scholarship Service in Princeton, N.J. The service analyzes the data on the form using what is known as the Congressional Methodology, a set of formulas established by the federal government that compare parents' income and assets and determine the maximum amount a family should be expected to pay for a college education. This calculation is the basis for allocating funds from most federal and state financial aid programs. WPI also uses the Congressional Methodology—with some modifications—to determine what a student can be expected to contribute toward its cost.

In a straightforward calculation, WPI's Financial Aid Office subtracts the family's maximum contribution from the total cost of attending WPI (this cost includes not just tuition and fees, but also the cost of room and board, books, and other student expenses). The result is the student's need.

"Once we've arrived at this figure, which we call the eligibility level," says Michael J. Curley, director of financial aid, "we try to meet it, as closely as we can, with the funds available to us."

Curley says his office can meet that need by drawing on some 180 endowed financial aid scholarship funds established over the years by alumni, friends and corporations. It can use unrestricted funds set aside in the Institute's budget. It can use grant funds allocated to WPI by the state and federal governments. And it can enroll students in federal self-help programs—work-study jobs and government loans.

Beginning with next year's freshman class, an applicant whose need is $6,000 or less will receive a financial aid package made up entirely of grant aid, Curley says. For a student whose need is more than $6,000, the package will include a combination of grant aid and self-help monies, the percentage of each being determined by a number of factors, the most important being the student's academic record. Because federal self-help programs have limits, either on the total amount of funds allocated to WPI or on the total that can be awarded to any one student, WPI is often unable to meet the full need of students whose requirements are high.

For example, Curley notes, an entering student can receive a maximum of $2,625 per year under the Stafford Student Bank Loan Program. The Perkins National Direct Student Loan Program has an upper limit that, for a typical student, works out to $2,250 per year. Students can receive a maximum of $1,200 per year from a work-study job. For a student whose total need is $13,000, WPI might meet 45 percent—$5,850—with grants, and the remaining portion with self-help. But because of the limits associated with the federal programs, the college can provide only $6,075 in self-help to this student, for a total financial aid package of $11,925. The student must come up with the remaining $1,075 from his or her own resources. In the lexicon of financial aid, he's been "gapped."

"When we first started using this approach to financial aid, no one was gapped," notes Voss. "Now, as our costs continue to rise, we must gap more and more students every year."

Why is the number of gapped students increasing? There are three key reasons, Voss says: the rising cost of attending WPI, the declining ability of WPI families to afford our costs, and the failure of federal financial aid expenditures to keep pace with the true cost of attending private colleges like WPI.

Between the 1985-86 and 1988-89 academic years, WPI's tuition rose by between

FIGURE 1. Cost of Attending WPI vs. Family Contribution

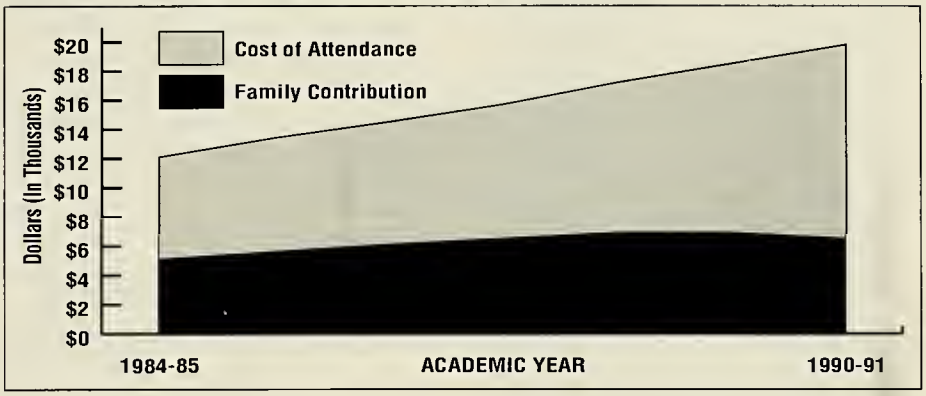
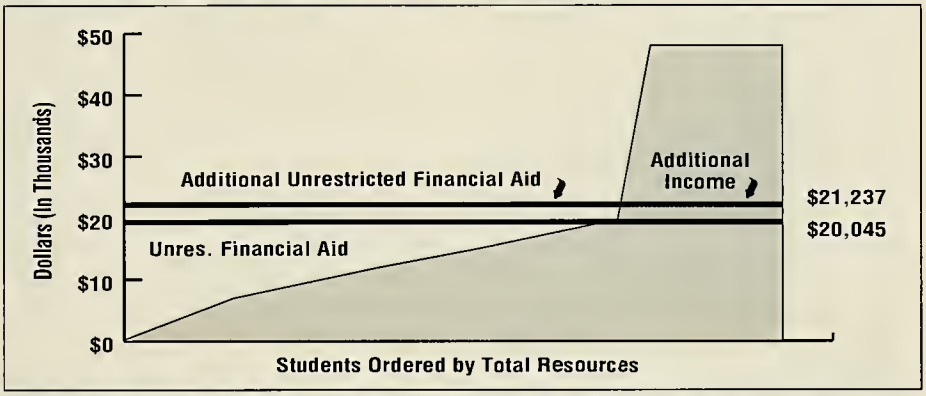


FIGURE 2. Student Resources, 1990-91 Academic Year



The top line in Figure 1 represents the total cost of attending WPI (including tuition, fees, room and board, and expenses) in any given year. The top of the black area represents the total amount an average family can contribute toward that cost from its own resources. The gray area in Figure 2 is a composite of the actual contributions of the families of all of WPI's undergraduates plus financial aid from non-WPI sources. The bottom of the horizontal gap represents WPI's current cost—$20,045—and the white area beneath this line is the unrestricted financial aid WPI will provide from its own budget this year. The top of the horizontal gap represents WPI's cost after a theoretical 6 percent tuition increase and the area inside the gap is the additional income from that increase. As you can see, most of that income (the part in white) would be spent meeting the cost of additional unrestricted financial aid, while only a small portion (the part in gray) would be realized as additional resources for the operation of the Institute.

9 and 11 percent each year. The amount the family of an average WPI student was able to contribute toward that cost increased more slowly during the period (Fig. 1), so the difference between WPI's total cost and the average family contribution—the void that must be filled with financial aid—rose from about $7,800 to about $10,200. During the following academic year, as WPI's tuition and fees rose another 9 percent, the average family contribution remained virtually constant. For the current academic year, WPI increased its tuition by 8 percent, while the average family contribution declined. As a result, the difference between cost and contribution is now about $13,000.

Why has the average family contribution been declining? "The economy is certainly the most important factor," notes David Cyganski, vice provost and vice president for information systems and services, who developed a computer model of the factors that influence WPI's financial aid costs. "The jobless rate in Massachusetts has gone from the best in the nation to one of the worst in just three years. Since about 50 percent of our undergraduates are from Massachusetts, that has a direct impact on our students' ability to pay. In addition, houses and other fixed assets are worth less than they were just a few years ago. Quite simply, the economy is not doing well and families are finding themselves with less money to invest in their children's education."

As college costs rose throughout the 1980s, the federal government kept its allocations for student financial aid essentially constant. According to the College Board, between the 1980-81 and 1988-89 academic years, while the cost of

Leonard E. Redon '73
Rochester, N.Y.

Director, Service Parts Management, Customer Equipment Services Division, Eastman Kodak Company

Student Years: *B.S. in chemical engineering, Skull, Lambda Chi Alpha, Professional Society, cheerleader, Honors Day Convocation usher, Newspeak, FM radio station, Masque, Camera Club.*

Alumni Years: *former alumni class agent.*

Redon joined Kodak in 1973 as a product development engineer. In 1988, after several other assignments, he became the first non-white to serve as assistant to Kodak's chairman and president. In 1988 he was named director of service parts management in Kodak's Customer Equipment Services Division.

His memberships include the Association of Field Service Managers, National Accounts Managers Association, Council for Logistics Management, United Negro College Fund, and the National Action Council for Minorities in Engineering.

"When I look back on my life and note those key events that have helped me achieve my goals," Redon says, "it is clear that the education I received from WPI is a seed from which much has grown. Without financial aid from WPI, an education of this caliber would probably not have been available to me. I see financial aid as the key that unlocks opportunity for those with the will, but not the means."

attending an average private four-year college rose by more than 123 percent, federal financial aid allocations (including Social Security, veterans benefits and Reserve Officer Training Corps funds) increased by 42 percent. In constant 1989 dollars, while college costs rose by about 52 percent, federal financial aid allocations actually declined by 3 percent.

To compensate for the lack of growth in federal financial aid dollars, many states increased their expenditures for financial aid. In fact, during the 1980s state financial aid spending rose by 123 percent, or 52 percent in constant 1989 dollars.

But, Curley notes, with the slowdown in the economy, many states may be forced to curtail their financial aid expenditures. Already, during the past year Massachusetts cut by more than half allocations made under its Gilbert Grant Program, a program that provides funds that private colleges can allocate to Massachusetts students. WPI's Gilbert funds were reduced from the $485,000 originally awarded last July to $233,000. Still, the college will receive the fourth largest allocation under the Gilbert program, an indication of the number of WPI students from Massachusetts who are in need of financial aid.

Colleges also increased their spending on financial aid during the 1980s. Spending by all colleges—public and private—rose by 178 percent (90 percent in constant 1989 dollars) during the decade. At WPI, spending on financial aid increased from $1.3 million during the 1980-81 academic year to $7.5 million during the 1989-90 academic year, an increase of nearly 480 percent.

Each February the WPI Board of Trustees must make one of the most important decisions of the year: how much to raise the Institute's tuition for the subsequent academic year. In large part, the decision is driven by such factors as the anticipated price increases for the materials and services the college purchases, planned increases in salaries and benefits, allowances for new hires and new programs, required debt service on loans, required maintenance on physical facilities, and so forth. Since the Institute derives much of its operating revenues from tuition, the increase the trustees approve assures, to a large degree, that the college will be able to meet its expenses and make the programmatic changes and improvements necessary to continue to offer a high-quality education.

In recent years this annual decision has become more and more difficult. With more than 70 percent of all undergraduates receiving some form of financial aid, any increase in tuition can be expected to have a substantial impact on the college's financial aid budget. Because the ability of families to contribute to WPI's costs is declining, when tuition goes up students currently on financial aid will see their need—and their requirement for aid—rise. And, students previously able to pay the full tuition might find themselves needing aid.

"In times of good economic growth, our students' need never went up as fast as our costs, because the real income of families was increasing," Voss says. "Before this current downturn, the ability of families to meet our cost usually grew by about $400 per year, or about $1,600 over four years. This past year, families' ability to pay actually went down."

The increased need for financial aid spurred by a tuition increase partially offsets the income the increase can be expected to generate to meet WPI's expenses. This effect is compounded by the annual increases in the other components that make up the total cost of attending WPI. While WPI can discount its own cost—its tuition—with financial aid, it cannot do the same to such student expenses as room and board and books. Students must pay the full amount of these costs, which make up about a third of the cost of attendance. Since financial aid calculations are based on this total cost—and not just on the cost of tuition—still more tuition income must be used to offset the annual increases in these additional expenses (Fig. 2).

As the gap between WPI's cost and parents' ability to pay widens, more and more of the income realized from the annual increase in tuition is consumed in meeting the increasing need of students. For example, if tuition were to rise by 6 percent for the 1991-92 academic year—one proposal under consideration at press time—just one-sixth of the increase would be available as additional income. The remaining five sixths would foot the bill for additional financial aid. In short order, should the college continue to increase tuition by six percent a year, the additional financial aid costs would more than wipe out the income from the annual tuition increase. In fact, in the 1992-93 academic year a 6 percent increase will result in a net loss to the college (Figs. 3 and 4).

Undergraduate tuition is not WPI's only source of income. Interest earned on the college's endowment, which has a market value of about $101 million, yields more than $5 million annually in unrestricted funds—about 10 percent of the Institute's budget. Gifts to the college, especially those to the Alumni Fund, last year generated about $2 million in unrestricted dollars. Tuition from graduate and continuing education programs and the summer school also helps the college meet its expenses.

But as it accounts for two-thirds of all income dollars, undergraduate tuition is the college's single most important source of revenue. If the college realizes little or no gain by increasing its tuition, it will likely find it difficult to balance its budget.

"If we were to go about our business as usual, with no changes or additional programs, just doing exactly the same things we're doing now, our expenses would grow by about 7 percent next year," notes Cyganski. "But, because of additional financial aid costs, with a 6 percent tuition increase our net tuition revenue would grow by just 1 percent. That would create a deficit of about $2.5 million, if we did not cut our expenses."

If the college continued to increase tuition 6 percent annually, each year would bring an additional $2 million or so in forced expense reductions. By the time the 1994-95 fiscal year rolled around, the Institute would be looking at a budget reduction of nearly $8 million (Fig. 5). "All of that represents increased financial aid costs," Cyganski says.

In simple accounting terms, to erase a budget deficit one must reduce expenses, increase income, or a combination of the two. Solving WPI's budget problems will require action on both sides of the economic equation, but it will also take some fundamental changes in the way the Institute carries on its day-to-day activities, notes Diran Apelian, provost and vice president for academic affairs.

"The challenge will be to cut our costs and improve our quality," he says. "That requires a certain mental attitude, something that the business world calls 'Total Quality Management.' With this attitude we at WPI will no longer think, 'If it ain't broke, don't fix it,' but rather, 'If it isn't perfect, let's make it better.' The keystone to this approach is accepting, as individuals, that we are going to change—that we are willing to change. And not just for the sake of change, but because there are better ways of doing the things we do. In fact, the difference between winning and losing will be how we view change."

In the near term the college's focus must be on immediate actions that can reduce costs and shrink the projected budget shortfall. Apelian says it is not reasonable to think that the college will immediately find new sources of revenue to supplement the monies that rising financial aid costs take away. "It is more controllable to contain costs, than to generate income," he says. "In an expanding economy, increasing your income is not that difficult, but we are not in an expanding economy—we are in a contracting economy. So for the next two to three years, we will have to find ways to control our costs."

FIGURE 3. Tuition and Fees: Increases

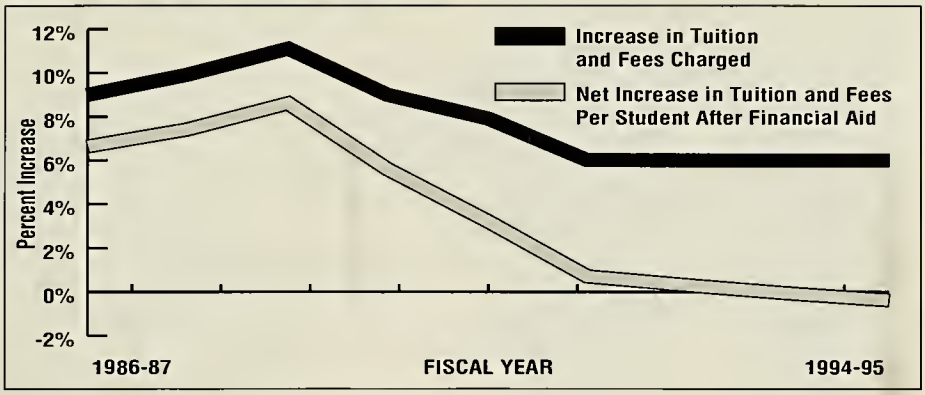
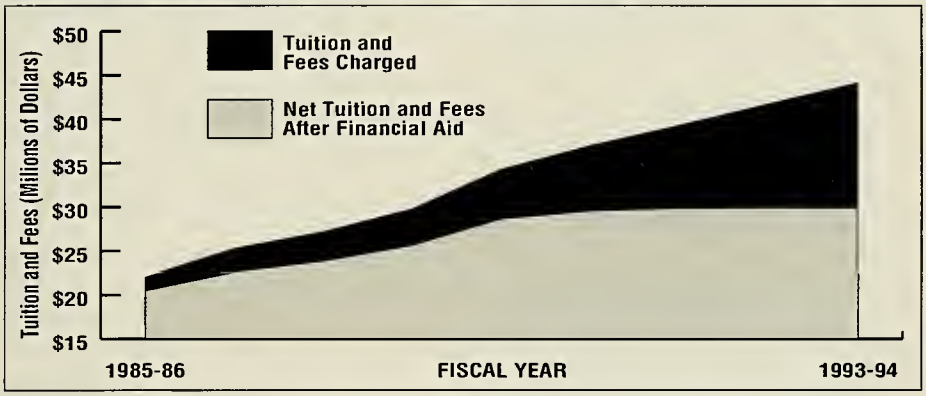


FIGURE 4. Tuition and Fees: Past, Present and Future



Figures 3 and 4 illustrate a common point: WPI has been realizing less and less in the way of additional income from its yearly tuition increases, as more and more of the income from these increases has been consumed meeting the growing need for financial aid. As Figure 3 shows, in the near future a six percent tuition increase would result in a net loss to the college. Figure 4 shows the total amount of funds WPI has charged its undergraduates in recent years and the amount of funds that would be charged with theoretical 6 percent tuition increases beginning with the 1991-92 academic year. The gray area is the amount of those monies realized as real income; the black area represents funds consumed to meet the increasing need for financial aid.

It is also unreasonable, Strauss notes, to think that fund raising will hold the answer. "We raised $11 million for financial aid in the *Campaign for Excellence*," he says. "That sounds like a lot, but you have to remember that $1 million invested in the endowment yields about $55,000 annually that we can actually spend. That buys nine average scholarship grants, four full-tuition scholarships or three full-cost scholarships.

"Looked at another way, our budget for the next fiscal year calls for us to spend $10 million of our unrestricted funds on financial aid. We'd need an additional $200 million in endowment to cover that. Just covering the annual increase in financial aid costs would require $40 million in new endowment each year."

Are there real opportunities for containing costs and increasing the productivity of WPI's faculty and staff? "We're looking at a number of opportunities," says Apelian. The possibilities, he adds, range from combining similar academic programs, thus reducing redundancy in program offerings, to assuring that student project teams have at least three students each, reducing the faculty's project advising load.

There may also be opportunities to cooperate with other colleges in the Worcester area to eliminate overlaps in academic offerings. "For example, instead of establishing new language programs to support our global project program," Strauss says, "we could make better use of the language programs already offered by other colleges in the Worcester Consortium for Higher Education."

Since financial aid represents one of the Institute's largest costs, are there ways to reduce this expenditure, perhaps by providing more aid money in the form of loans? Should WPI follow the example of Smith College, which, faced with an annual increase of 20 percent in its financial

KIMBERLY M. FAY '86
NASHUA, N.H.

Second-year M.B.A. student, Harvard Business School

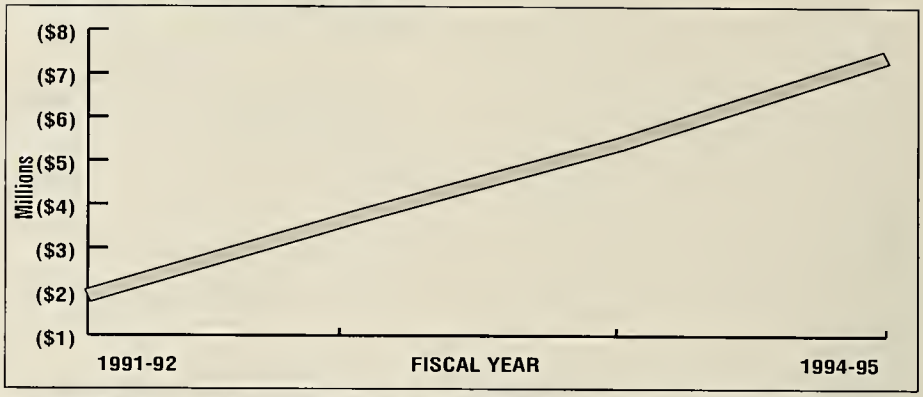
Student Years: *B.S. in management, Phi Sigma Sigma, eucharistic minister, IFC representative, Skull, Washington Project Center, basketball, lacrosse, Varsity Club, Management Society, Professional Society, Student Alumni Society, Presidential and Vice Presidential Search committees.*

Captain of the women's varsity basketball team, Fay was named most valuable player in the first round of the NCAA basketball tournament in 1983. In her junior year she surpassed 1,000 points and was designated an NCAA Academic All-America basketball player.

Fay held a summer internship as an industrial engineer in Norton Company's Business Orientation Program. After graduation she was a management trainee with General Electric, and later served as a materials support specialist for GE in Plainville, Conn. After receiving her M.B.A., she plans to enter the field of brand management or product marketing.

"I cannot tell you how much the Financial Aid Office, along with the whole WPI community, supported me from Day One," she says. "I'm from a modest background with hardworking parents. Because I received the Walter and Miriam B. Rutman Scholarship during my first two years at WPI, my parents were able to send my three younger brothers to college, as well. Receiving financial aid has meant everything to my future."

FIGURE 5. Revenue/Expense Targets



This graph shows the projected budget shortfalls the Institute could expect beginning with the next academic year should it choose to increase its tuition by 6 percent each year.

aid costs, abandoned its need-blind admissions policy? Beginning with the next academic year, Smith will rank its undergraduates and, starting at the top of the list, meet the full need of eligible students until the money runs out.

"It is our perception that our financial aid practices, and the packages we are able to offer students, make it possible for us to meet our enrollment targets," Strauss says. "Significantly changing the way we handle financial aid could jeopardize our competitiveness.

"Cost cutting and cost containment have to be the first steps," he emphasizes. "The next phase will be bringing our prices better into line with the ability of our student population to pay. In essence, that means keeping our price under control until the ability of our students to pay catches up."

Beyond these approaches, WPI will be exploring ways to attract more students who can afford to pay all—or at least most —of the cost of attending the Institute. Records maintained by the Admissions Office show that each year students who can afford to pay WPI's full costs make up a higher percentage of the applicant pool than of the entering freshman class. Getting a better handle on why students choose not to attend WPI may enable the Institute to better market and present itself to these applicants. This job will be tackled over the next few months by a newly created marketing task force, headed by trustee John M. Nelson.

Meeting that challenge may be as simple as better educating prospective students about the qualities that make a WPI education unique, notes Strauss. "We must differentiate ourselves from our competitors on the basis of our quality. We know there are many students out there who want to go to a technological school and who have the ability to pay. We have to demonstrate to them that we are the best place for them to go."

Given that one-third of WPI's revenues already come from sources other than undergraduate tuition, should WPI consider adding new programs to appeal to new classes of students? Are there opportunities to build the undergraduate enrollment by adding new programs to attract students interested in nontechnical fields? "Adding new programs is something you do in an expansionist economy—when you have the income to do it," Strauss says. "But beyond that, there is the question of what we really want to be. Fundamentally, we educate high-quality undergraduates to be first-rate practicing professionals in engineering, science and management. That is our mission. We can make changes at the fringes, but if we alter things too much, we risk changing what we are."

Still, notes Apelian, there may be opportunities to capitalize on the strengths of WPI's existing educational offerings to create academic foci that can increase the Institute's reputation and its appeal to a broad range of students. "For example," he says, "in 40 years there will be 12 billion people on the Earth. That population growth will create serious environmental and social issues—issues that we can address. As a technological university, our role is to serve society by educating the next generation of custodians of the Earth. I think this is a role for which WPI is uniquely suited.

"You have to create a wave," Apelian adds, "and then ride it. You can't wait for the right wave to come along. I think we have enough intellect here, enough resources, enough historical capital, and enough respect for each other, to go forward and find the right solutions."

The Changing Face Of Financial Aid

Colleges are in a tough spot these days, and Worcester is no exception. Costs are up and endowment income is down, so the fees paid by students are more significant than ever in the financial scene....In the present trying years, when so many capable boys might otherwise be denied an education, the Institute has given scholarship aid up to the very limit of its resources."

Those words seem apt today, but they appeared in the *WPI Journal* in 1935. Back then, the Great Depression made it difficult for most students to afford WPI's tuition, creating a strain on the Institute's financial aid resources. In fact, the issue of student aid has never been far from the minds of administrators throughout WPI's history.

In a sense, financial aid was part of the founding principal of the Institute. When John Boynton gave his life's savings of $100,000 in 1865 to create a new college, he stipulated that residents of Worcester County should receive instruction without charge. Reflecting this wish, the trustees named the new institution the Worcester County Free Institute of Industrial Science.

A few months after it opened its doors, the college sought funds to help meet the financial needs of state residents who hailed from outside the county. The Institute asked for and obtained $50,000 from the state to establish 20 full-tuition scholarships for these students.

The college continued to admit all students from Worcester County tuition free until 1889, when it was announced that county residents—who then made up about two-thirds of the total enrollment of 150—would attend free of charge only as far as the income from the student aid funds could be stretched. That year the funds paid the way for 40 students.

In 1873 trustee George Frisbie Hoar made one of the earliest recorded gifts to establish scholarships at WPI. The Hoar Fund enabled three students from Norfolk County in Massachusetts to attend tuition-free. The state awarded the college another $50,000 in 1886 to be used, in part, for financial aid, and the following year the commonwealth established annual awards (which grew to $15,000 by 1910) to maintain 40 scholarships, one for each of its senatorial districts.

Noting that MIT and the Agricultural College at Amherst (now the University of Massachusetts), the two institutions designated Massachusetts land-grant colleges under the federal Morrill Act, had received sizable government subsidies, WPI trustee Charles G. Washburn in 1912 asked the state for an annual allocation of $50,000 to maintain WPI's 40 state scholarships.

"The Institute is in imperative need of financial aid. The average annual deficit for the past 10 years has been large, making it necessary to draw upon such of the endowment funds as are necessary for this purpose, which are now nearly exhausted," noted a college report to the state that year. The state consented, but ceased the annual grants in 1922.

In 1919, as part of a drive to build its endowment, the college inaugurated the sustaining, or industrial, scholarship. For each $10,000 in gifts, a local company could select an employee or a son of an employee to receive free tuition at the Institute. Leading Worcester manufacturers contributed $375,000 to create these scholarships.

A number of loan funds were created at the Institute during the 1920s by alumni, friends and industry, but the college seemed less than successful in getting students to repay their loans. In 1928 WPI President Ralph Earle wrote to those who owed money saying, "The fact is that the Institute, because of its liberality and its efforts to help students today, has no money at all for student loans despite the fact that its Student Loan Fund now amounts to $23,269."

The Depression created an enhanced need for student financial aid at WPI. By 1931 the Institute had established several "emergency scholarships" to help students pay their way; in 1932 the Institute voted to accept notes for tuition. "In looking forward to 1932-33 there is apprehension as to how we may meet the students' requests for loans," a college report noted that year.

The federal government entered the picture in 1934 with the passage of the Walsh-Guyer Bill, which set aside money to help needy college students by providing them with part-time campus jobs. This Federal Emergency Relief Administration program helped substantial numbers of WPI students. In 1935 about 200 students —more than a third of the enrollment— were receiving aid, in full or in part, totaling $40,000.

By 1964, 70 percent of WPI students were receiving financial aid in the form of scholarships or loans. Two years later President Harry P. Storke told a Parents' Day luncheon, "No student at Worcester Tech has ever paid in tuition and fees more than two-thirds of the actual cost of his education here. For the past 50 years that ratio has held quite constant...The other third comes from endowment fund income and from gifts, et cetera." Though students had once been able to work their way through WPI, this was becoming a thing of the past, he added.

In 1969 the Institute for the first time began funding student financial aid from its operating revenues and reserves. Previously, aid monies came entirely from endowed and grant revenues, the 1969-1970 Annual Report noted. Aid from all sources awarded to 568 students that year totaled $776,000, an increase of 37 percent over the previous year.

The need for financial aid continued to grow during the 1970s and early 1980s. In 1975 students received about $1.4 million from all sources. That figure rose to about $4.5 million in 1983 and to $8.3 million by 1986. For the 1990-91 academic year, that figure is $20.7 million.

Today, as the cost of providing a high-caliber education in engineering and science continues to grow, and as the declining economy takes its toll on the ability of WPI students and their families to pay their way, the price WPI must pay to keep its doors open to all qualified students—a commitment that began with the dream of John Boynton and has been nurtured through the generosity of alumni and friends through the years—promises to climb still higher.

—Neil Norum

The Smallest of Factories

By Paul Susca

The biotechnology industry is already harnessing cells to make a host of valuable products—from life-saving drugs to new types of pesticides. At WPI, biochemical engineers are learning more about growing these living assembly lines and recovering their products.

They work tirelessly, never sleeping. They work cheaply, needing warmth, food, oxygen and little else. They make a wide range of goods, many of them extremely valuable. They seldom make mistakes. And, they take up very little space. They may become the workhorses of the 21st century. They're living, genetically engineered cells, and researchers at WPI are working to make them do their jobs even better.

"What we do," explains William Clark, assistant professor of chemical engineering, "is apply the techniques of chemical engineering to biochemical systems, so we call it biochemical engineering."

Clark and David DiBiasio, associate professor of chemical engineering, are at the center of a number of collaborative efforts aimed at advancing the technology of biochemical engineering. James Rollings, associate professor of chemical engineering, is the third member of WPI's biochemical engineering research team. His work focuses on the characterization of biopolymers (*WPI Journal,* Winter 1986).

"The cell," Clark says, "is basically a little factory that's continuously producing the materials it needs to survive and to carry out its functions." With the advances genetic engineering has made during the last 20 years, he adds, scientists can now program cells to produce a broad range of substances that are foreign to them, but which have value to people and industry. "If you can make cells produce a product you're interested in, then you have a bunch of little factories working for you."

Research on genetic engineering and biotechnology has typically fallen within the larger realm of biology, but chemical engineering also has a crucial role to play in this emerging industry. Currently, chemical engineers are bringing decades of experience in reactor dynamics and process engineering to bear on the unique challenges associated with growing living cells and harvesting their products.

These two aspects of biotechnology—the performance of biological reactors and the separation of biochemical products—will prove vitally important to the continued growth and success of the industry. In their research at WPI, Clark's specialty is separations, while DiBiasio's work focuses on the bioreactor.

One way to operate a bioreactor is to treat it like a black box. Cells (these might be microorganisms, such as yeast, fungi or bacteria, or cells from higher organisms, such as Chinese hamster ovary or baby hamster kidney) and growth media go in, and a mixture of cells, media, cell products, byproducts and waste material come out. But, DiBiasio says, by learning more about how cells grow and behave in a bioreactor—in other words, by peering inside the black box—one can design reactors that help cells do their manufacturing work more successfully.

"Genetically engineered microbes don't like to be genetically engineered," DiBiasio says. "They have plasmids—bits of foreign DNA—stuck into them that code for products they don't normally make. In the process of reproducing they will often lose these plasmids."

When bacteria lose the plasmids inserted into them by the genetic engineer, they lose the ability to make the product they were engineered to produce. Therefore, in some instances it is desirable to maintain working bacteria in an environment that limits their rate of reproduction.

Bacteria tend to reproduce more

JANET WOODCOCK

Maura Collins '91 removes a sample of gel-coated beads, which contain immobilized *E. coli* cells, from an experimental apparatus while (left to right) Judith Miller, Christina Barcus '91, and graduate student Morey Kraus observe.

slowly—and to put the bulk of their energy into making product—when they are confined. There are several ways to confine bacteria. DiBiasio and Judith Miller, associate professor of biology and biotechnology, confine cells in a gel they coat onto small plastic beads.

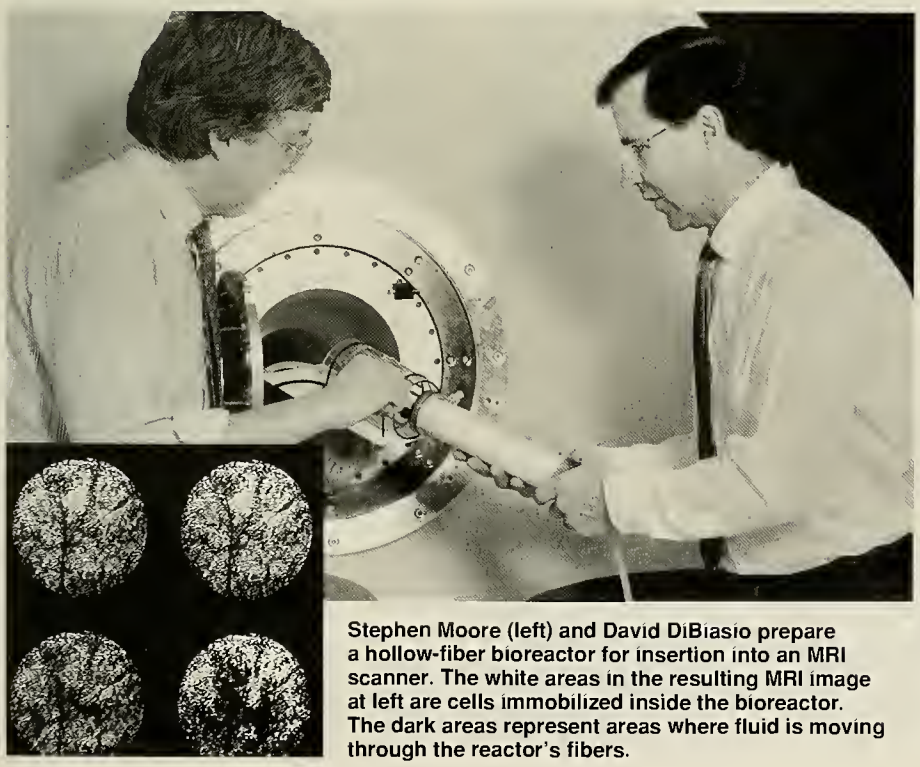
While the gel confines the bacteria, it also isolates the cells somewhat from the nutrient-rich broth in which the beads are suspended. This may impair their ability to obtain needed raw materials and to get rid of their waste products. In fact, Miller and DiBiasio expected that when they grew *E. coli* (a bacteria widely used in genetic engineering) in a gel, the high concentration of waste products—especially acetic acid—would inhibit the ability of the bacteria to produce a specific protein. Instead, the immobilized cells appeared to be more productive than cells that are allowed to float freely.

"We don't know for sure whether enough acetic acid accumulates around the cells to actually affect their metabolism," Miller says, "or if it diffuses away freely enough so that it doesn't become a problem. We have a lot of work yet to do to find out if the metabolic changes we see—particularly the increase in productivity—are a result of the limited diffusion in the gel, or some other aspect of immobilization that we haven't yet defined. We'd like to know exactly what it is about immobilization that causes these changes."

Initially this research looked at the production of an enzyme that *E. coli* makes naturally, using a gene located on the bacteria's own chromosome. Now Miller, DiBiasio, Ph.D. student Morey Kraus, and undergraduates Maura Collins '91 and Christina Barcus '91, who are completing their Major Qualifying Project (MQP), are looking at the production of an enzyme encoded by the DNA of an *E. coli* plasmid. Since engineered genes are introduced into bacteria in plasmids, this protein is a good model for a recombinant DNA-derived product with a practical application.

Grown in large stirred tanks—with or without bead-like supports—genetically engineered *E. coli* are used commercially in the production of a wide range of products, including human insulin and interferon. But *E. coli* and other microorganisms lack the machinery to attach side chains to certain proteins, particularly those that are of value

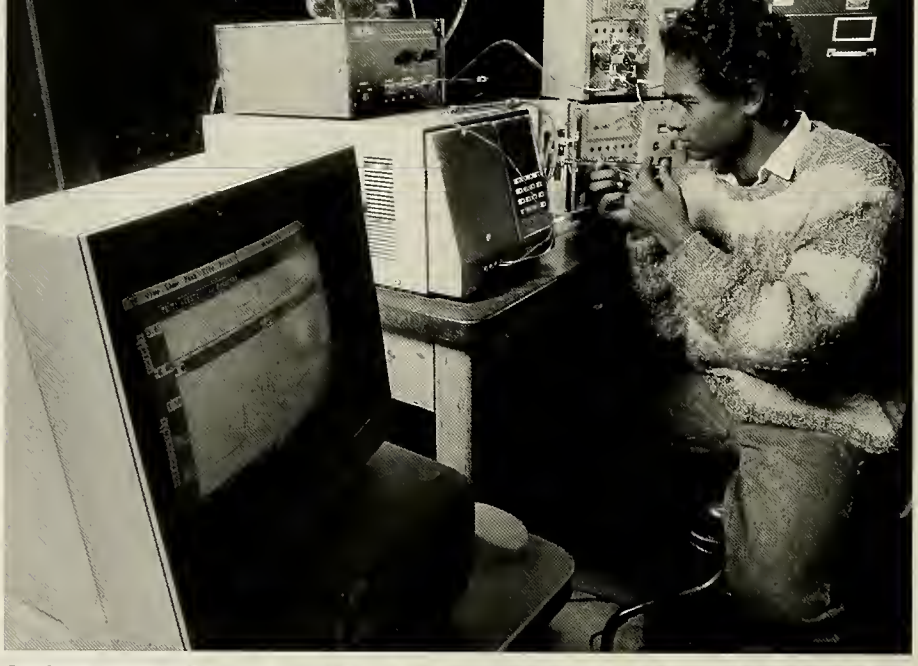
JANET WOODCOCK



Stephen Moore (left) and David DiBiasio prepare a hollow-fiber bioreactor for insertion into an MRI scanner. The white areas in the resulting MRI image at left are cells immobilized inside the bioreactor. The dark areas represent areas where fluid is moving through the reactor's fibers.

as human therapeutic agents. It is often those side chains (typically sugars) that make the final product active and therefore of economic value.

Cells from higher organisms, particularly mammals, have the ability to complete the assembly of high-value biomolecules. But mammalian cells are not as easily cultured as microorganisms. For one thing, they are sensitive to the sheer stresses caused by turbulent mixing in stirred tanks. And, mammalian cells need to attach themselves to a surface before they can go to work producing desirable molecules. As a result, bioreactor research has recently begun to emphasize the design and operation of devices that can be used to culture mammalian cells.



JANET WOODCOCK

Graduate student Manish Singh injects a two-phase solution into a high-performance liquid chromatography unit, one of a number of separation techniques under study at WPI.

DiBiasio holds up a clear plastic tube slightly smaller than a can of tennis balls. The tube appears to be packed with uncooked spaghetti, the individual noodles running from one end of the tube to the other. The noodles are actually thousands of hollow fibers and the tube is a hollow-fiber bioreactor, designed to culture mammalian cells. The cells grow in the spaces between the fibers, and cell growth medium flows through the insides of the fibers themselves.

The hollow-fiber bioreactor has been the focus of several projects done under DiBiasio's guidance. The work began when Ph.D. student Charles Sardonini, now an employee of a Framingham, Mass., biotech company, approached him with the idea of studying the growth of cells around the fibers.

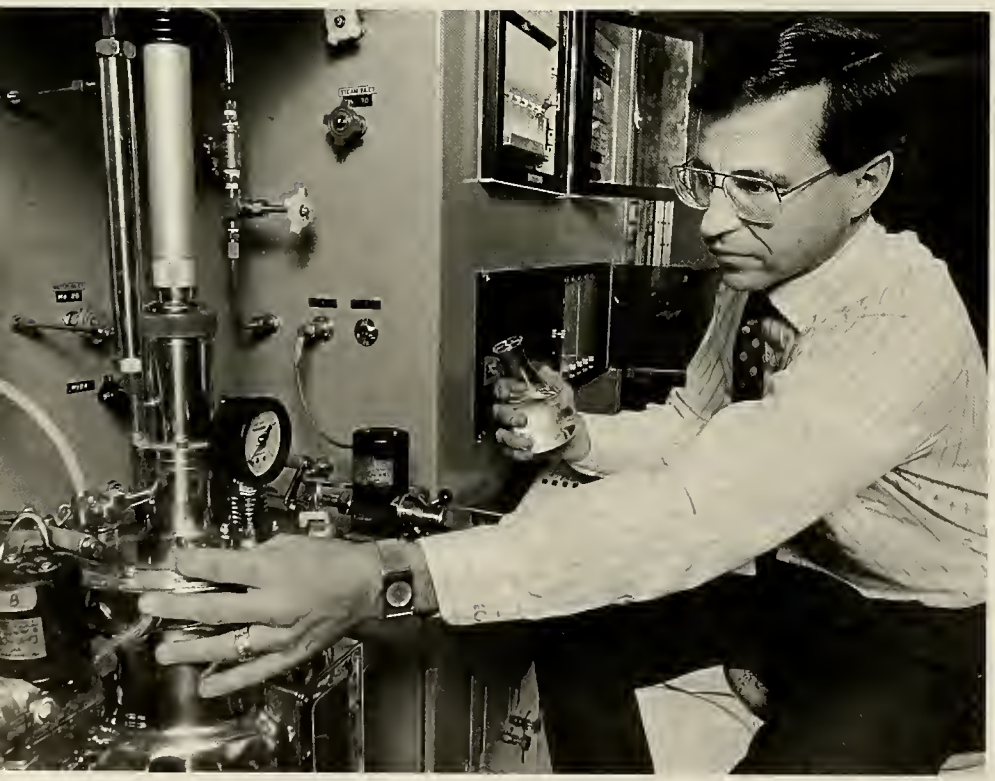
"There were a number of mathematical models in the literature to describe and predict the operation of hollow-fiber bioreactors—all based on ideal situations around a single fiber," DiBiasio says. "But there wasn't a lot of experimental checking and verification at the single-fiber level."

Sardonini constructed simplified reactors with between one and 50 fibers, and then recorded cell growth around the fibers using photographic and other methods. It was already known that the growth of cells in hollow-fiber bioreactors is complicated by the fact that the fibers are not rigid and therefore are not evenly spaced within the reactor. As a consequence, cells grow densely in some areas and sparsely in others. By studying various cross sections within the tube, Sardonini devised a model that describes the growth and distribution of cells throughout the entire reactor.

Another little-understood aspect of hollow-fiber bioreactors is the way in which fluid flows through the devices, especially given the uneven packing of the fibers. That topic caught the attention of Ph.D. student Brian Pangrle, also under DiBiasio's guidance. After several frustrating attempts to measure fluid flow using such novel techniques as fiber-optic probes and x-ray movies, Pangrle hit upon the idea of using magnetic resonance imaging (MRI).

Pangrle had learned about MRI, a medical imaging technique based on the absorption of energy by atoms subjected to a strong magnetic field, in a biomedical imaging course at WPI. The Institute runs a research-scale MRI scanner in collaboration with the University of Massachusetts Medical Center at the Massachusetts Biotechnology Research Park in Worcester.

According to Stephen Moore, associate professor of biomedical engineering, who,



JANET WOODCOCK

DiBiasio fine-tunes a 20-liter bioreactor, a device that provides a carefully regulated environment for the growth of microorganisms such as yeast and bacteria.

along with biomedical engineering Ph.D. student Edward Walsh, worked with Pangrle on the MRI portion of the project, the MRI studies provided useful information on the flow of fluid through an "empty" bioreactor —one into which no cells have been introduced.

Building on Pangrle's work, DiBiasio, Moore, Walsh, and a team of undergraduates working on their MQP, went on to develop a way to employ MRI to gather data on the distribution of fluid velocities in each part of the reactor under a variety of conditions. That work earned the students (Christine Donoghue '90, Michelle Brideau '90 and Patricia Newcomer '90, all chemical engineering majors) first place at the 1990 New England regional student paper competition sponsored by the American Institute of Chemical Engineers.

More recently, Moore and DiBiasio have worked with another MQP team to obtain MRI images that show the density of cell growth within hollow-fiber reactors. "This work tells us about the pattern of cell growth," DiBiasio says, "but we need to do some additional experiments to show that we can develop more specific information on how the cells actually behave in the reactor."

For the initial experiments, DiBiasio and Moore will use bioreactors—already packed with cells—discarded by the company where Sardonini works. The aim of the experiments will be to couple the fluid-flow work with the cell density work, providing information on the relationship between fluid flow and cell growth. That information should prove useful to biotechnology companies that use hollow-fiber reactors, DiBiasio says.

Even when biotechnologists find ways to get mammalian cells to produce sufficient quantities of biomolecules,

Kresge Challenge Hits the Homestretch

Biochemical engineering is one of several research disciplines that will find a home in WPI's new bioprocess technology laboratory. The facility, now nearing completion on the fourth floor of the Salisbury Laboratories building, will provide a modern, state-of-the-art environment for education, project work and research in critical areas of biotechnology.

"Two of the greatest challenges that face most biotechnology companies are downstream processing, the separation and purification of the products of biochemical processes, and scale-up, the enlargement of biotechnology systems from the laboratory scale to the commercial scale," says Judith Miller, associate professor of biology and biotechnology. "The new lab will be one of a very few facilities in the country that can train undergraduates to meet these challenges."

Funds for constructing and outfitting the new 1,600-square-foot lab have been received from a number of sources, including the W.M. Keck Foundation and the National Science Foundation. In the fall of 1989 The Kresge Foundation awarded the Institute a $350,000 grant for renovations and equipment purchases. To receive the Kresge funds, the college must raise—by May of this year—an additional $1. 3 million to create a permanent endowment that will provide for the maintenance of the laboratory and the purchase of new equipment

At press time, with nearly three months remaining before the deadline for the Kresge Challenge, the Institute had raised close to $718,000, or about 55 percent of the goal. Contributions have been received from individual alumni, corporations, and friends of the Institute. They include an $82,500 grant from the Worcester-based Hoche-Scofield Foundation, more than $368,000 in anniversary gifts from the classes of 1940, 1950 and 1965, and more than $166,000 from parents of WPI students and alumni.

Work on the new laboratory is entering the final stages, Miller says. Among the remaining work is the installation of a number of pieces of laboratory equipment that have been donated by manufacturers or made available to the Institute at significant discounts. These include two computer-controlled fermentors—one with a 50-liter working volume—and several shakers made by New Brunswick Scientific Company Inc.; a centrifuge and a "smart" spectrophotometer made by Beckman Instruments Inc.; a centrifuge from Jouan Inc.; fraction collectors from Isco Inc.; a cell disrupter manufactured by Microfluidics Inc.; a peristaltic pump from Bacon Technical Industries Inc.; electrophoresis equipment from Hoeffer Scientific Inc.; and filtration and high-pressure liquid chromatography units, along with a $25,000 purchase credit, from Millipore Corp.

When the lab is finished later this year, it will host existing courses in fermentation and downstream processing and a new course in scale-up. The laboratory will also be used for training sessions for the regional biotechnology industry and will be made available under rental and contact arrangements to biotechnology firms.

"When the fermentation, downstream processing and scale-up courses are all under way in the new lab, WPI will have a virtually unmatched capability in bioprocess technology education," Miller says. "With the endowment created by the successful completion of the Kresge Challenge, we can assure that WPI maintains that edge for many years to come."

JANET WOODCOCK

Students will perform lab and project work in this area of WPI's new bioprocess engineering laboratory, now nearing completion in Salisbury Laboratories.

they may run into problems as they try to separate the desired product from a mixture of culture broth, nutrients, byproducts, additives, cell fragments and even whole cells. For decades, chemical engineers have been devising new ways to perform separations for chemical systems, but, as Clark points out, when compared to conventional chemical separations, bioseparations present an entirely new set of problems.

"In a simplified sense, in a chemical reaction, you add A to B and you get C," he explains. "You can control how much A you add in order to use up most of the B. If you control the reaction well, you'll use up all of A and have some B left over, so you'll have to separate C from B."

But bioseparations present engineers with a much more complex mixture than a simple blend of two chemicals. Also, biomolecules tend to be very sensitive to their environment. "Most chemical engineering separations today are done by distillation," Clark says, "but you can't use distillation in biochemical engineering because the molecules are sensitive to heat." High heat will typically cause proteins to denature, or unfold, thereby losing their biological activity, which is partly a property of their three-dimensional shape. Strong solvents used widely in chemical separations will also cause biomolecules to denature.

Biomolecules also tend to be produced in very dilute solutions—a thousand to a million times less concentrated than the products of typical chemical processes. "The more dilute the product, the more expensive it is to separate," Clark explains. "So if the product doesn't have a high market value, you're in trouble."

Biochemical processes also call for extremely pure end products, especially if the products are to be used clinically in humans, where even minute amounts of impurities can cause life-threatening side effects.

Clark is developing several techniques to deal with the challenges posed by bioseparations. At the top of his agenda is the use of aqueous two-phase solutions—solutions of polymers (or a polymer and a salt) in water. Nature requires that the energy of molecular interactions within a solution be minimized, and for certain concentrations of polymers a solution can lower its energy by splitting into two layers, or phases, much as a mixture of oil and water does.

The solution that Clark works with most often is a mixture of polyethylene glycol (PEG) and dextran. Because PEG and dextran are incompatible in solution, a mixture of the two in water tends to separate into a layer of PEG-rich solution on top and a layer of dextran-rich solution on the bottom.

Aqueous two-phase separations provide an environment that is safe for large biomolecules likely to denature in the presence of the harsh solvents used in many chemical engineering separations. To separate a biological product with such a solution, one creates a mixture in which the product tends to concentrate in one phase while the other components of the growth solution tend to concentrate in the other.

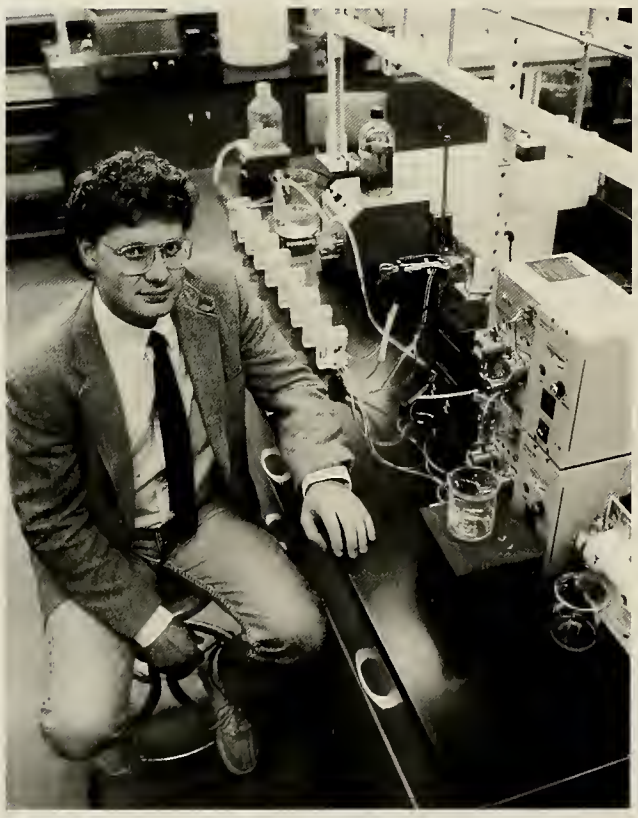
"You could end up with slightly more of the product in the top phase and slightly more of the materials you don't want in the bottom phase," Clark explains. "To increase your yield, you could do the separation over and over again, each time exposing the bottom phase to fresh top phase. But you would like to minimize the number of times you have to do this, and increase the selectivity of the phases for your product."

There are several ways to increase the selectivity of the separation. One is to add salts to the system. The salts create a charge difference between the two phases, which influences the partitioning of charged product molecules. Another way is to add a functional group, called a ligand, to the polymer molecules. Properly chosen, the ligand can attach itself to the product molecules much like complementary pieces of a jigsaw puzzle.

Since biochemical systems tend to be highly specific in their interactions, Clark, working with master's degree students Pradyumna Godbole, Ruey Tsai and Manish Singh, has exploited a naturally occurring ligand-product interaction to enhance affinity partitioning. The product of interest is the antibiotic vancomycin, which works by selectively binding with a peptide (a chain of amino acids) in the wall of a target cell. Adding the peptide's last two amino acids to polyethylene glycol thereby enhances the affinity of vancomycin for the PEG phase. The ligand-vancomycin bond can later be released by changing the pH of the solution.

This type of affinity partitioning has yet to reach the commercial stage, Clark says. One reason is that it is expensive to make the ligands on a large scale and to recover them after the separation. Rather than attach ligands to polymer molecules, Clark has also begun to use beads with ligands attached to them in two-phase systems. The large beads are easy to recover and reuse, but present other problems, since products must first diffuse into the beads before they can attach to the ligands.

MICHAEL OORSEY



William Clark with a prototype of his electropartitioning system. The unit continuously separates proteins from a two-phase solution as the solution flows through an electric field.

The question of scale is an important aspect of the biotechnology industry's interest in new separation techniques. "The traditional chemical engineer takes a laboratory discovery that a chemist makes and scales it up into a large-scale, economic, continuous process," Clark says. "In the world of biochemistry we would like to do the same thing, but it turns out that with biological molecules one gram may be worth several million dollars and be a year's supply for the world. So you don't always need the kind of scale that chemical engineers are used to."

At the other extreme are simple biomolecules such as ethanol and lactic acid, which can be produced either by microorganisms or by chemical synthesis, but are needed in much larger quantities and can be separated by conventional chemical engineering techniques.

But the area where advances in bioseparations are likely to have their greatest impact, Clark argues,

JANET WOODCOCK

Clark and graduate student Aseem Bansal examine a ceramic membrane with a scanning electron microscope. The micrograph at right shows (clockwise from lower right) a complete image of the membrane (IM), and parts of the membrane that contain phosphorous (P), aluminum (Al) and tungsten (W). The white areas in the tungsten image are proteins deposited on the surface of the membrane.

is between these two extremes—complex biomolecules needed in intermediate quantities whose value is sufficient to justify elaborate separation schemes.

With intermediate-scale processes in mind, Clark has worked with a number of undergraduates completing their MQPs, including Ricardo Icaza '89, Bruce Denis '90, Kenneth E. Hamilton '90, Kimberly Johnson '91, Megan Moore '91 and Melanie Wallace '91, and with graduate student Charles Theos, to take two-phase aqueous systems one step beyond affinity partitioning into what they call electropartitioning.

Knowing that charge differences produced by salts or charged polymer molecules can enhance the partitioning of a desired product, Clark's team theorized that adding electrodes to a two-phase system would also enhance partitioning. They tried it, and it worked.

"Once we got started, we realized that we were actually doing electrophoresis (the use of an electric field to induce charged molecules to migrate toward the oppositely charged electrode), which is a very efficient small-scale separation process," Clark says. One of the problems with the conventional use of electrophoresis in separation, however, is that some heating occurs at the electrodes, creating convection currents that tend to remix the solution. Separation by electrophoresis in a two- phase solution, however, is aided by the sharp, stable boundary between the two phases. Convective mixing may occur within each phase, but it is not likely to cross the boundary, Clark says.

Clark's team developed an apparatus that uses electropartitioning on a continuous basis by applying an electric field to a two-phase system that flows through a horizontal tube with electrodes on the top and bottom. "It works quite nicely," Clark says. "The phases, well-mixed, flow in one end; they separate as they flow through the device, with the protein going to one phase or the other." The technique has the potential, Clark says, to combine the high selectivity of electrophoresis with the ability of two-phase systems to be scaled up.

The other area in which Clark's team is active is the use of membranes—materials with microscopic pores—for bioseparations. Membranes made of organic polymers (such as the cellulose acetate fibers in the hollow-fiber reactors that DiBiasio and Moore work with) are widely used in the biotechnology industry, but Clark and Ph.D. student Aseem Bansal are focusing on ceramic membranes, which, while more expensive, are more readily sterilized and reused. One of the problems posed by ceramic membranes is that their pores tend to become clogged, either with particles too large to pass through or by molecules that adsorb to the inside surfaces of the pores.

In collaboration with Yi Hua Ma, professor of chemical engineering, and Ronald Biederman, professor of mechanical engineering, Clark has been developing a method of tagging proteins with tungsten so that sequential x-ray images of the membrane taken during a separation will reveal the membrane fouling process. Working with a team of MQP students, DiBiasio says he hopes to couple the x-ray data with MRI data on flow fields within hollow-fiber reactors to provide a comprehensive picture of how proteins foul membranes.

"Biotechnology and bioseparations are very old fields," says Clark, "if you consider that the ancient Egyptians made wine and then filtered it." But the marriage of genetic engineering with biochemical engineering is embryonic by comparison. Clark, DiBiasio and their collaborators are asking many fundamental questions about how the technology works, and how it can be made to work better.

Susca, a freelance science writer in Rindge, N.H., has written frequently for the Journal.

One Hundred Years of Fiji

Members of WPI's oldest fraternity, Phi Gamma Delta, relax on the porch of the chapter's first house in 1897.

EDITOR'S NOTE: *This year, as WPI celebrates the 100th anniversary of its Alumni Association, the Institute pauses to light 100 candles for Pi Iota Chapter of Phi Gamma Delta, the first Greek letter fraternity established at WPI. Pi Iota's birthday celebration officially gets under way April 13 at the chapter's annual Pig Dinner. For the following story, we are indebted to current alumni advisor Walter Knapp '38, a nationally honored member of Phi Gamma Delta, for his extensive research.*

The bonds of friendship at college are often of the strongest nature and last all through life," noted an article in an 1891 issue *The WPI*, a former campus magazine. "And in the opportunities for making acquaintances among the students all are aware that the Institute is deficient. We have no dormitories, few social gatherings, little outside of study and recitation." To bridge the yawning gap between academic life and social life on campus, some students had attempted a few years earlier to introduce a scientific and agricultural fraternity—called QTV—to WPI, but the effort failed due to lack of interest. Student discontent over the lack of extracurricular outlets was continuing to build, however, and in 1891 the time seemed ripe to try again.

According to fraternity archives, Fred Morse, Albert Culley, Hugh Southgate and William Nelson, all members of the Class of 1892, and William Stark and Richard Cleveland of the Class of 1893, founded the Pi Iota Chapter of Phi Gamma Delta that year. Most were former members of QTV. That November, the chapter inducted eight charter members: the six founders and William Burleigh '92 and Ralph Morgan '94. Another early inductee was Harry Dadmun '91, winner of the intercollegiate half-mile championship in 1890 (he notched a record that stood for nearly 40 years).

Following the untimely death of Fred Morse shortly after graduation, the Pi Iota governing organization was named the F.A. Morse Building Association in his honor. The name and association have endured to this day.

One of the earliest social functions at the original chapter house, located at 7 Highland Street where the Worcester County Court House now stands, was a formal reception for trustees and faculty. According to *The WPI*, "Through the efforts of the committee the house presented a

very pretty appearance, the halls, parlors and dining room being decorated with palms, ferns and cut flowers...A very pleasant evening was spent, the members of the fraternity enjoying the occasion of meeting the professors and their wives socially, and will look forward to the time when they can entertain them all again." In 1899, following a brief move from Highland Street to Everett Street, construction began on the current chapter house, a three-story, brown and white colonial structure at 99 Salisbury Street. The estimated cost then was $20,000.

The campus magazine described the completed house: "Crossing a broad piazza in front, one enters the spacious reception hall extending back nearly the full length of the house. The finish here is antique quartered oak with hangings of dark green. On the left is the reception room, finished in pink with white woodwork.

"The woodwork in the smoking room and library is finished in green, and the paper is heavy, plain crimson. A cream-colored brick fireplace adds a comfortable tone to the smoking room. This will be the most frequented room in the house."

The new fraternity, which offered many opportunities to its members, rapidly grew in popularity. Over the years it assumed a leadership posture on campus. For example, it was reported in 1907 that Phi Gams were elected to all four of the class president positions and that in every campus organization a brother held at least one important post.

Socially, Phi Gamma Delta has become noted for its annual Fiji Island bash, for which the chapter house metamorphoses overnight into an exotic tropical paradise complete with thatched huts and sea shells. Although the uninitiated might assume that this annual rite gave the Phi Gams their nickname, actually the reverse is true, according to Phi Gam Roy Seaberg '56, director of special admissions at WPI.

"Phi Gamma Delta has never used initials as a nickname, as many Greek fraternities do." he says. "The Phi G. part of the fraternity name got shortened to 'Fiji' early on." Adds Knapp, "When my grandfather was in school, he was taught to pronounce Phi as Fee; hence Fee Gee or 'Fiji.' The annual Fiji Island party was a natural outgrowth of the established fraternity nickname."

Another long-standing Pi Iota tradition is the periodic painting of the rock in front of the house in fraternity colors: purple and white. Seaberg says the custom was started in the 1960s by then chapter president William Cullen MacDonald '62. "He objected when the city painted the stones in Institute Park white," says Seaberg, "so he got the brothers to paint the rock nearest the house in our colors. Occasionally other fraternities dumped paint over the rock, but the Fijis always redid it in purple and white."

The rock is still popular, serving as a billboard for advertisements, a chapter house marker and a landmark for the city of Worcester. Many people have come to identify the rock and its ever-changing character with WPI.

In the winter of 1977-78 the rock was stolen—reportedly by a rival fraternity—and never recovered. Thanks to the resourcefulness of Bob Guigi '79, a replacement of much larger mass was obtained. But in the fall of 1980 the brothers returned to WPI to find that the City of Worcester had removed the new rock along with the rest of the boulders surrounding Institute Park.

Brother Dave Green '81 came through this time with the tools, materials and initiative to replace the rock. This new specimen, even larger than its predecessors, is still there, greeting passersby and willingly accepting frequent coats of paint.

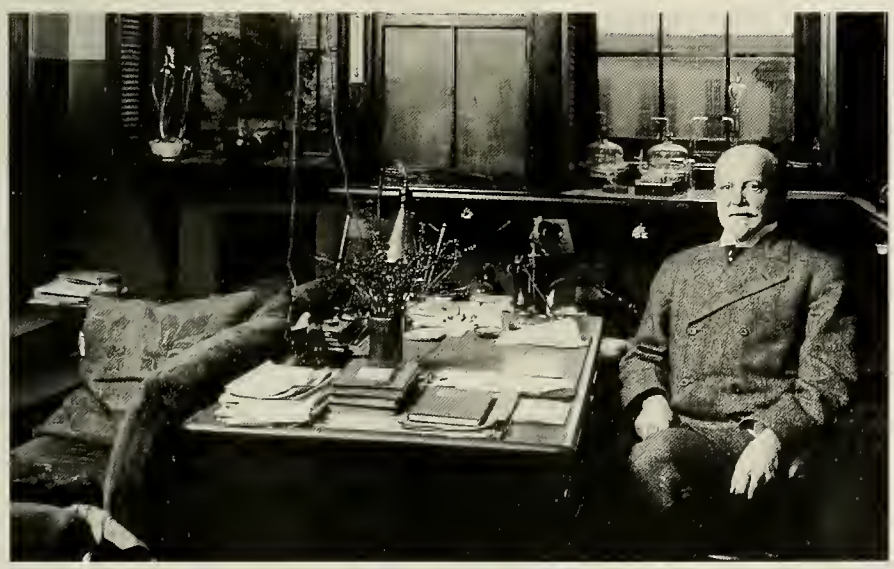
In 1921 Ted Coghlin '23 brought the fraternity's Cheney Cup (awarded for exemplary conduct as evidenced by scholarship, campus activities and fraternity relations) back to Worcester by train from Phi Gamma Delta's national convention. Pi Iota won the cup again in 1972. The chapter's ongoing service to the community through the Big Brother program helped it win an honorable mention in the competition for the national fraternity's Baker Social Service Cup. In 1976 Pi Iota retired WPI's Interfraternity Council sports trophy for winning the IFC sports competition three years out of five.

In 1976 and 1981 Walter Knapp received the fraternity's coveted national Durrance Award as the best chapter advisor. The late Leland Atwood, former head of WPI's History Department, won the award in 1965-66, the first year it was awarded.

In 1899 Chemistry Department head Leonard Kinnicutt, for whom Kinnicutt Hall on campus is named, became the first faculty member to be inducted into the chapter. The late Allan Parker, longtime head of WPI's Physics Department, was also an active leader with the fraternity.

Several early members of the fraternity went on to illustrious careers. Some became significant benefactors to WPI. Robert Parks '93, for example, a 60-year executive with Parks-Cramer Co. and a WPI trustee, left the college more than a million dollars. Trustee Henry Fuller '95, vice president of Fairbanks, Morse & Company, funded WPI's swimming pool and the Yankee Ingenuity Scholarship. Ralph Spaulding '09, vice president of Aetna Steel Company, provided funds through a surprise bequest for graduate fellowships and building renovations.

Wayne Keith '22, general supervisor for New England Telephone and a vice president of the WPI Alumni Association, was the first alumnus to serve as chairman of



Leonard Kinnicutt, longtime professor and Chemistry Department head, was the first member of the WPI faculty to be inducted by Phi Gamma Delta.

Phi Gamma Delta's original house (opposite page) and its current three-story home on Salisbury Street (above).

the Board of Trustees. During his tenure the college constructed five buildings and moved toward the development of the WPI Plan. Alexander Naylor '28, president of The Fairbanks Co., established a WPI scholarship fund.

Outstanding in service to their fraternity and to WPI as undergraduates, many other Pi Iota members have risen to prominence on the national scene. For example, trustee emeritus C. Marshall Dann '35 was U.S. commissioner of patents and trademarks for three years. Others, like trustee emeritus Phillip Delphos '26, retired New England district manager of Riley Stoker Corp. and a past president of the Alumni Association, have earned praise for their service to WPI alumni affairs. Delphos' son, William Delphos '74, a trustee, is president of Venture Marketing Corporation in Washington, D.C.

Caleb "Bud" Hammond '37, a WPI trustee emeritus, is chairman of Hammond Inc., makers of maps, atlases and globes. Walter Abel '39, retired vice president and senior fellow of technology at Emhart Corp., was instrumental in establishing WPI's Manufacturing Engineering Applications Center. Chandler Jones '26 retired in 1968 as vice president of New England Electric System. John Lott Brown '46, a WPI trustee emeritus, is president emeritus of the University of South Florida.

Another Pi Iota luminary, trustee emeritus Hilliard "Hilly" Paige '41, a past president of General Dynamics Corp. who is now chairman of H.A. Knott Limited Inc., a firm specializing in video-conferencing systems, is a consultant to the Department of Defense and the Department of Energy. Prior to his retirement in 1986, John Metzger Jr. '46, a WPI trustee emeritus, was group vice president of the Photo Systems and Electronic Products Department of Du Pont. The late Charles Inman '14, one of the founders of the WPI Alumni Fund and a charter member of the Tech Old Timers, was also a brother.

Also among the ranks of Pi Iotas are Edwin "Ted" Coghlin Jr. '56, president of Coghlin Electrical Contractors Inc. in Worcester; Henry "Pete" Cummings Jr. '50, president of Lowell Corp. in Worcester; Stephen Rubin '74, president and CEO of Intellution Inc. in Norwood, Mass.; David Demers '74, president of Demers Associates Inc. in Lunenburg, Mass.; Louis Frascotti '79, vice president of American Protection Insurance Co. in New York City; and John J. West Jr. '88, president-owner of EnviroCorp. Inc. in Leominster, Mass., and the winner of *Central Massachusetts Business Digest's* 1990 "Young Entrepreneur of the Year" award.

Longtime advisor Knapp is rightfully proud of his extensive list of successful Pi Iota advisees, many of whom he has kept in contact with for decades. He is a strong and vocal supporter of the fraternity system.

He says he believes profoundly in the statement of those WPI editors 100 years ago that "the bonds of friendship at college are often of the strongest nature and last all through life." For Knapp and hundreds of his current and former Fiji advisees, those kindred bonds have bridged generations.

— Ruth Trask

Many Phi Gams have distinguished themselves in service to WPI. Robert Parks '93 (left) was a trustee and a major donor; Wayne Keith '22 (at right in this photo with President Harry Storke) was the first alumnus to chair the Board of Trustees.

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John Boynton and the Revolution in Higher Education

BOYNTON
HALL

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Front Cover: Surrounding a drawing of WPI's founder, John Boynton, are items from the WPI Archives that tell the story of his extraordinary gift that created the Institute. At the top is one of architect Stephen Earle's original renderings of Boynton Hall. At right and left are tin boxes made in Boynton's Templeton, Mass., factories, the source of his modest fortune. In the box at left is the list of assets Boynton turned over to WPI (attested to by Stephen Salisbury II, chairman of the Institute's first Board of Directors); in front is the Institute's charter from the commonwealth of Massachusetts. At bottom, beneath Boynton's walking stick (now carried by the honorary marshall each year at Commencement), is the letter Boynton dictated to Worcester minister Seth Sweetser explaining his aims for the Institute. Story on page 2; photo essay on page 14. Photo by Janet Woodcock. **Opposite:** Spring blossoms decorate the entrance to Boynton Hall. Photo by Robert S. Arnold. **Back Cover:** Professors David P. McKay and Laura Jehn Menides stroll through the Mountain View Cemetery near McKay's home in Shrewsbury, Mass. Story on Page 18. Photo by Janet Woodcock.

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THE SECOND

By Donald F. Berth '57

In the latter half of the 19th century, men like WPI's own John Boynton founded a whole new type of educational institution to train a new professional class of scientists and engineers. In the process, they helped set the stage for a great period of technological and economic expansion. Here are their stories.

Two hundred years ago, on May 31, 1791, John Boynton was born in the small hamlet of Mason, N.H., which lies just 10 miles north of the Massachusetts border. While most readers know something of the career of WPI's founder (a look at Boynton's life in words and photographs begins on page 14), and of his investment that led to the establishment of the Institute, many may be unaware that WPI was part of a vanguard that materially altered the direction of education—particularly education for career preparation—in this country.

Well over a century ago, at a time when this nation was still in a relatively primitive state of economic development, men like John Boynton, Peter Cooper, Asa Packer and Ezra Cornell realized that America's freedom, enterprise, innovation and prosperity were closely linked to the development of scientific and technological talent.

They recognized that while many factors contribute to our material and social well-being, the most important are how productively we can make goods and provide services, and how well we can husband our natural resources. Knowing that both of these factors depend heavily on the quality and quantity of the nation's applied scientists and engineers, they founded new types of institutions designed to educate these professionals. In their own way, the founders were as much pioneers as the thousands who crossed the American continent in covered wagons.

While the beginning of formal (i.e. classroom) education in engineering and industrial science in the U.S. can be traced to the founding of the United States Military Academy at West Point in 1802 and Rensselaer Polytechnic Institute in Troy, N.Y., in 1824, technical education was largely a post-Civil War phenomenon. Before the war, institutions like Harvard, Yale, Union College and Norwich University had developed programs designed to better prepare graduates to succeed in the American Industrial Revolution (and all have engineering programs today), but, unlike West Point and RPI, these colleges and universities let their programs lay fallow for many years.

Part of the reason so few technical institutions had been established by the time of the Civil War was the myopic vision that prevailed in this country more than a century ago of what higher education was about and who it was meant to serve. In 1860 there were nearly 300 colleges in America. Most were small denominational institutions with one of two objectives: to train clergy or to educate the "gentleman class" (a very small class in egalitarian America).

Another problem was that no one quite knew how to design a collegiate program to replace the apprentice or "shop floor" training model that produced the "electricians" and "mechanics" of the day. And, presuming one could transfer industrial training from the shop to the campus, where was one to find the money to build facilities and hire instructors?

Clearly, if engineering and the applied sciences were to develop as fields of activity worthy of learning—and, given the slow pace of change in the academy, if this were to happen in time to meet the demands of an increasingly industrialized nation—a new orthodoxy had to be created quickly. In fact, virtually all the major private institutions in the U.S. (and most of the public ones, as well) in which education in engineering and the applied sciences now figure prominently were established between 1862 and 1892.

It would be interesting to speculate, were there to be a new wave of schools designed to prepare engineering and science professionals for the 21st century, how the character of these new institutions might differ from those that exist today. While our modern colleges and universities often seem to bear little resemblance to the institutions they were during their founding years, upon close inspection virtually all have experienced evolutionary, rather than revolutionary development—and for obvious reasons.

Creating the institutions that arose during the 19th century required a small number of individuals of means who were interested in investing at least part of their wealth in something of higher purpose than self-indulgence. Recall that in the latter half of the 1800s public secondary schools, public libraries and major cultural institutions (museums and symphonies, for example) were not part of the experiences of the average American family. Many Americans didn't live anywhere near the few learning centers that existed then, nor did they have the time or the resources to take advantage of them.

1858

American Revolution

It took a few discerning individuals like John Boynton and the men and women whose lives are described in the next several pages to set the stage for the first great revolution in American higher education. The institutions they founded incorporated pioneering educational innovations. For example:

- The blending of classroom instruction with a working industrial (job shop) laboratory was a unique contribution of WPI. It placed the apprenticeship on the campus rather than in the factory.
- The first organized curriculum in mechanical engineering was created by Robert H. Thurston at Stevens Institute. Thurston also pioneered faculty-directed teaching laboratories that more closely coupled lab work to classroom instruction.
- The first large-scale blending on one campus of programs in classical studies and career education (especially engineering, agriculture and veterinary medicine) took place at Cornell.
- The first curricula for electrical engineering were developed at MIT and Cornell, with the first graduates emerging in 1885.

Equally important to the success of this revolution in American education was the Morrill Land Grant Act, which was signed into law by President Abraham Lincoln in 1862. It allowed for the formation of at least one college in each state whose principal objective was to advance the state of agriculture and the mechanic arts.

It isn't surprising that the creator of this landmark legislation, Senator Justin Morrill, was a New Englander (a Vermonter to be more precise). Much of what passed for higher education in 1860 could be found in the Northeast, largely because the region had had a head start on founding institutions of higher learning. In addition, business and industry were more established in this region than elsewhere in the country.

Therefore, the need for a new professional class to help lead the Industrial Revolution, as well as an appreciation for how colleges and universities might produce those new leaders, was more keenly felt in the Northeast. In fact, most of the major engineering institutions launched during the latter half of the 19th century were founded by individuals born in New England and New York.

While there seemed to be many individuals ready and able to create new colleges and universities during this period, good ideas were a little harder to come by. The founding premises for these new schools were captured either in vague notions or in lofty principles. There were some common threads, however, and these can be found in the personalities and characters of the founders themselves.

Most of the founders were successful businessmen, some having achieved success at the national level. Some, like Boynton, Asa Packer (Lehigh), Peter Cooper (Cooper Union), Andrew Carnegie (Carnegie-Mellon), Chauncey Rose (Rose-Hulman) and Ezra Cornell (Cornell) came from humble beginnings and did not have the benefit of formal education. They were motivated by the desire to help poor young men become successful and productive without having to endure the toil and poverty they had known. They never forgot their own early circumstances, even though their acquired wealth had made most of them into Victorian gentlemen. Those who made their fortunes through enterprises that required skilled workers were motivated to create more sophisticated types of education.

Interestingly, unlike successful businessmen of today, who have neither the time nor the intestinal fortitude for service in elected office, many of these founders served in state legislatures or, in the cases of Asa Packer and Leland Stanford, in the U.S. Congress.

At the start, most American colleges of science and technology offered a free education, or charged students only a nominal fee (even by the standards of the times). WPI was founded as the Worcester County Free Institute of Industrial Science. Lehigh was free until 1891. Rice and the Cooper Union were also free, Rice until the 1960s and the Cooper Union to this day.

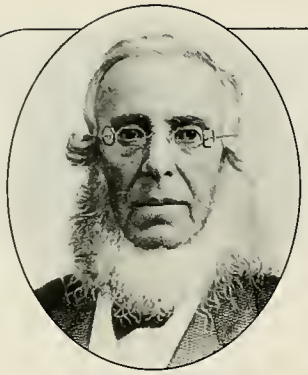
The early graduates of these institutions (those who received their degrees between the 1870s and 1900) began their careers in a world that was being transformed by landmark inventions. Telephony had its beginnings in the late 1870s; the first electric power generating station was built in 1883; steam power had overtaken water power in providing energy for manufacturing; and the great era of industrial inventors, characterized by men like Edison and Westinghouse, was under way. Shortly after the turn of the century, the development of the automobile created vast demands for machined parts, steel, forgings, rubber and petroleum products.

What began as a 19th century educational revolution, namely the establishment of colleges like WPI that had industrial science and technology as their major focus, set the stage for the great transformation that would turn the United States into the world's largest economic, scientific and technological power by the middle of the 20th century.

So, happy birthday, John Boynton, and thanks to you and to the handful of others who dared to dream dreams that have become great.

1900

Berth, vice president for university relations at WPI, is the author of several articles on the history of engineering education, many of which appeared in ENGINEERING: Cornell Quarterly, *a publication he founded 25 years ago this spring and edited for many years.*



Peter Cooper

Peter Cooper and the Cooper Union for the Advancement of Science and Art

Born in New York City in 1791, Peter Cooper was the son of a working-class immigrant. When he was still quite young his family moved to Peekskill, N.Y., where, at the age of 7, Peter got a job boiling the hair out of rabbit skins used to make hats. He later helped his father build a brewery and worked there for a few years.

When he was 17 he moved back to New York City to learn the basic skills of coach making and worked in that business, earning board and $25 a year, for about four years. With the $2,000 he earned in a progression of odd jobs, he bought a glue factory when he was 30 and quickly built it into an enterprise earning as much as $100,000 a year.

A conservative businessman, Cooper maintained no debt; he converted much of his factory's profit into Manhattan and Baltimore real estate. Buoyed by the success of the Erie Canal, which provided direct access to Midwest commerce and business, several Baltimorians obtained a charter for a railroad to link their city and Ohio. Cooper realized that a successful railroad would make his Baltimore land increase rapidly in value.

To keep track-laying costs down, the developers of the Baltimore & Ohio planned to curve the track around rocky hillsides. But George Stephenson, the English engineer who built the first steam locomotive, insisted that the engines of the day could not manage such sharp bends.

Cooper modified the Stephenson design to produce *Tom Thumb*, an engine capable of handling the hairpin curves. It was the first American locomotive to run on American track. His invention made the venture possible, and when he sold his Baltimore land holdings in 1832 they had grown fivefold in value.

During the Panic of 1837 a manufacturer to whom he had lent $5,000 to build a wire factory went bankrupt, and Cooper turned his attention to wire making. With the demand for wire and structural iron for railroads, telegraph lines and bridges, his Trenton Iron Co. thrived.

Cooper achieved all of this with just one year of formal schooling. Still, his limited education and hard early years made an indelible impression on him. A colleague had once told him how hundreds of young men from all over France were living on bare crusts of bread to attend lectures at a polytechnic school in Paris, and Cooper realized how important such a school would have been to him in his youth. That vision was the driving force behind the founding of the Cooper Union.

"I determined to do what I could to secure the youth of my native city and country the benefits of such an institution," Cooper wrote of the college he was determined to found, "...and throw its doors open at night so that boys and girls of this city, who had no better opportunity than I had to enjoy means of information, would be enabled to improve and better their condition, fitting them for all the various and useful purposes of life."

In May 1858 the first building, for which Cooper's company furnished the steel, was completed. The word "Union" was engraved on the front, with "Science and Art" chiseled on the other side. Foreseeing the approaching revolution between North and South, Cooper chose "Union" to emphasize the importance of sustaining a unified nation of states. The building had a 900-seat Great Hall, which added to the early recognition of the Cooper Union as a forum for new and exciting ideas. It was there in 1860 that Abraham Lincoln delivered his "Right Makes Might" speech, which is credited with winning him the presidency.

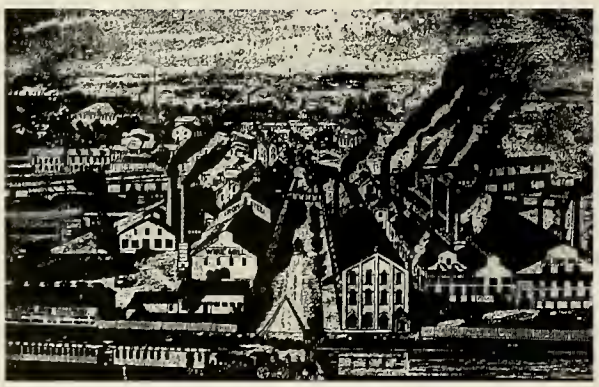
The Cooper Union's original building in New York City, completed in 1858.

In the fall of 1859 the first students were admitted—tuition free—to what was initially a night school of design for women, and a well-stocked reading room open to the general public (the only library of its kind in the city). Eventually the three schools that today make up the Cooper Union for the Advancement of Science and Art (architecture, art and engineering) emerged.

Throughout his middle years Cooper played an active part in public affairs in New York. He formed a close friendship with Joseph Curtis, superintendent of the House of Refuge for juvenile delinquents, and worked with Curtis on a number of projects, developing a deep respect for young people less fortunate than he had been. For nearly 20 years, as one of the trustees of the Public School Society, he made weekly visits to public schools.

In 1876, when the U.S. celebrated its centennial, Cooper was 85. He ran for president on a radical, third-party ticket, but received just 1 percent of the vote. He did live to see his son, Edward, and his son-in-law, Abram Hewitt, serve terms as mayor of New York.

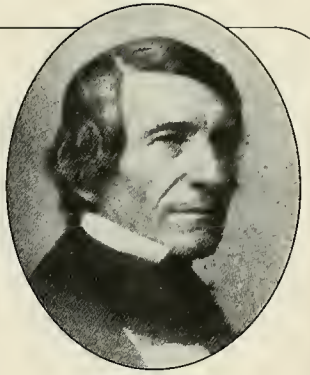
Peter Cooper's example was not lost on a host of future founders of higher educational institutions. The thrust of his philanthropy—the product of his hard work, inquisitive mind, and desire to be of service to his community—was helping others find a better way of life.



Cooper made part of his fortune from the Trenton Iron Co. in New Jersey.

1858

William Barton Rogers and MIT



William Barton Rogers

The nation's second oldest institution of applied science and technology had a distinctive beginning. Unlike many similar institutions, it was not the brainchild of a prosperous entrepreneur or businessman, though it would receive considerable help from several during its early formative period.

William Barton Rogers, MIT's founder, was born in Philadelphia in 1805. He was one of four brothers, all of whom became scientists, thanks no doubt to the influence of their father, a professor of natural history and chemistry at Virginia's College of William and Mary. Rogers attended William and Mary and, at the age of 23, assumed the natural history chair when his father died. In 1835 he was attracted to the University of Virginia, where he spent the next 18 years as professor of natural philosophy.

However, he became deeply troubled by the bigotry and student violence at the university, and by the erratic support from the state legislature. In 1845 he went on a geological expedition to New England with his brother Henry, and later wrote, "I have been unable to shut out the contrast between the region in which I live and the highly cultivated nature and society of glorious New England."

Richard MacLaurin helped MIT relocate.

On an excursion into the White Mountains of New Hampshire, William and Henry met the family of James Savage, a wealthy and scholarly Bostonian. William married Savage's eldest daughter, Emma, in 1849, but it wasn't until 1853 that the couple moved to Boston. Henry, who had long dreamed of founding a polytechnic school, accepted a post at the University of Glasgow in 1857.

In 1859 the governor of Massachusetts proposed that some of the land created by filling in what is now Boston's Back Bay (west of the Public Gardens) be used for educational purposes. The state legislature turned down two proposals for the land, but in 1861 allocated one-third of it for the creation of a museum of natural history and two-thirds for the establishment of Massachusetts Institute of Technology (then known as Boston Tech). The governor signed the bill into law on April 10, 1861.

The committee that submitted the successful proposal, which was headed by Rogers, claimed MIT "would be largely conducive to the progress of the industrial arts and sciences throughout the Commonwealth." The institute, it was said, would offer studies "suited to the various professions of the Mechanician, the Civil Engineer, the Builder and Architect, the Mining Engineer, and the Practical Chemist." The committee promised to raise $100,000 for the new institute and was given a year to do so.

Four days later, on April 14, 1861, Fort Sumter fell, signaling the start of the Civil War. Though the war retarded the initial development of the new institution, MIT held a meeting of incorporation in 1862 and elected William Barton Rogers president. That July Abraham Lincoln signed into law the Morrill Land Grant Act, which allowed for the creation of a fund to endow at least one college in each state to teach agriculture and the mechanic arts. Three-tenths of Massachusetts' share went to MIT. After a year's extension, the institute finally raised the required $100,000 when Dr. William Walker, a wealthy retired physician, agreed to make up the nearly $60,000 balance.

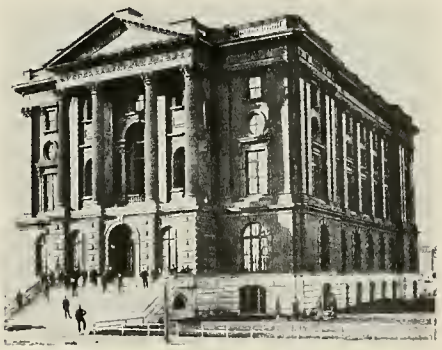
Construction on the first building began in 1863 on Newbury Street. Before it was finished, Rogers started teaching physics to 15 students in the Mercantile Library in downtown Boston. That fall the building (today a men's clothing store) was ready to accommodate the first class of 72 students and a faculty of 10.

Among the earliest faculty members attracted by Rogers were Charles W. Eliot and Francis Storer, both of whom taught chemistry. Eliot, who had been head of the chemistry department at Harvard's Lawrence Scientific School, returned to Harvard to become its president in 1870 and oversaw the transformation of that college into a major university during his long tenure.

In 1868, at the age of 63, Rogers suffered a slight stroke while attending a faculty meeting. He resigned two years later. He lived until 1882, when he died on the platform during MIT's commencement ceremony.

Twice during its early history, proposals were floated to merge MIT with Harvard. In 1904, for example, Eliot and MIT president Henry S. Pritchett, together with a majority of MIT and Harvard trustees, sought to merge the two institutions, despite vigorous opposition from MIT alumni and faculty. The merger depended upon MIT's selling its Boston property for a handsome price. MIT was saved by the Massachusetts Supreme Judicial Court, which ruled that the sale would violate the terms under which the Institute had originally received the property. That finished Pritchett, and shortly thereafter MIT hired Richard C. MacLaurin as its next president.

MacLaurin realized that the Institute needed more space. The positive press of four Cambridge civic associations and a favorable resolution passed by the Cambridge city council made possible a move to a site on the banks of the Charles River. Between the du Ponts (T. Coleman '84, Pierre '90, Irenée '97 and Lammot '01) and George Eastman, who donated about $20 million, enough funding was provided to set the institute on a new course in the second decade of the 20th century. Though MacLaurin died in 1920 at age 49, he lived long enough to ensure the realization of the youthful dreams of William and Henry Rogers.



MIT's original building on Newbury Street in Boston.

1862

Ezra Cornell

Ezra Cornell and Cornell University

The eldest of 11 children, Ezra Cornell was born in 1807 in Westchester Landing, N.Y. He grew up on the family farm in upstate New York, about 40 miles from Ithaca, where he moved at the age of 18 to begin earning a living. Over the next several years he worked as a carpenter, a mechanic and a millwright.

With a wife and several children to support, he suddenly found himself unemployed during the Panic of 1837. With his meager savings he bought the Maine and Georgia patent rights to a new type of plow and went on the road to promote its use by farmers in those states.

One day he found himself in the office of *The Maine Farmer*, a small country newspaper. Its editor, Francis Ormand Jonathan "Fog" Smith, wanted to design a plow capable of digging a trench, inserting a telegraph wire enclosed in a pipe, and then covering it—all in a single operation. A skilled mechanic, Cornell was captivated by Smith's idea, and within a month had fabricated such a device.

Smith had won the contract to run wire between Baltimore and Washington, D.C., at the rate of $100 a mile for the first long-distance test of the Morse Telegraph. With his new plow, Cornell began laying pipe in October 1843, but after completing 10 miles of cable discovered that defective insulation was permitting electricity to leak into the ground. Cornell came up with an ingenious solution: covering the copper wire with cotton saturated with gum shellac, and then stringing it between poles. To insulate the wire from the poles, he developed a bureau-drawer-knob type of glass insulator. On May 1, 1844, the line was completed; 23 days later Morse tapped out the first public telegram: "What Hath God Wrought?"

Cornell helped build a number of telegraph lines in the East, working initially for Magnetic Telegraph Co. He accepted part of his wages in the form of company stock, a strategy he followed with several other telegraph companies. He later became an agent for Fog Smith, who had acquired the Morse patent rights in the Midwest.

Meanwhile, in Rochester, N.Y., Hiram Sibley and Samuel L. Selden had come to an important conclusion: If the telegraph industry, with its more than 50 competing companies, was to grow, it needed to be organized into an efficient, unified system. Cornell decided to combine his considerable telegraph investments with those of Sibley and his associates. At Cornell's suggestion, the competing lines were organized under the name Western Union Telegraph Co. It was the first successful attempt to join independent communications systems into a central network. It would later become the model for the national telephone network.

Burdened with a heavy load of debt, Cornell returned to Ithaca in 1856 to begin a new life as a farmer. But he held on to his Western Union stock, which in short order generated enough income to cover his debts. His wealth and reputation grew rapidly after the first transcontinental telegraph line was completed on Oct. 24, 1861. He served a term in the New York State Assembly and was elected to the state Senate, but declined to run for re-election in 1867. By then he was earning close to $150,000 a year.

Andrew D. White, first president of Cornell.

Ezra Cornell resolved to dedicate his growing fortune to the promotion of education and to aiding the development of Ithaca. He contributed $100,000 for a free public library in the city and, in February 1865, pledged $500,000 to establish a new university there. A bill to create Cornell University was introduced in the New York Senate, where Andrew D. White, Cornell's Senate colleague and friend, helped move it along. Of more importance, White helped win for the university the proceeds of New York's share in the Morrill Land Grant Act. The bill was signed by Governor Reuben E. Fenton on April 27, 1865 (just 13 days before WPI's charter was signed by the governor of Massachusetts). This action made the new university both private and public.

Civil engineering students in Cornell's Class of 1884 during the annual summer surveying camp.

White, an urbane, well-educated scholar, became Cornell's first president. He was born in 1832 in Homer, N.Y., about 25 miles north of Ithaca. (Homer is also the birthplace of the late George W. Hazzard, WPI's 11th president, who earned his doctorate at Cornell.) White did his undergraduate work at Yale, much to the chagrin of his father, who had wanted him to attend nearby Geneva College (now Hobart College).

After traveling and studying in Europe, he returned to Yale to earn his master's degree. The death of his father and the start of the Civil War cut short a brief career as a professor at the University of Michigan. A man of considerable wealth, largely in-

1865

herited from his father, White was, to his surprise, nominated and elected to the New York Senate.

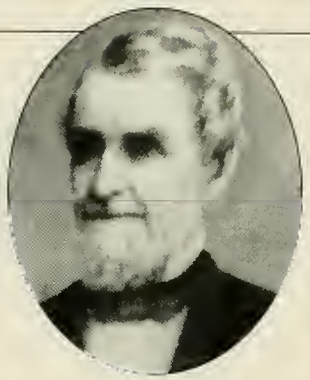
Andrew White's intellectualism was the ideal balance to Ezra Cornell's agrarian, entrepreneurial and mechanic skills. It was White who persuaded Cornell, who had intended for his university to emphasize studies in mechanics and agriculture, to permit the humanities and the classics to stand as equals alongside those disciplines. This model stood in stark contrast to the classical universities and colleges of the day, which taught the classics and humanities almost exclusively.

Unlike virtually all other colleges and universities of the time, Cornell had no religious affiliation. In 1868, 412 students began classes at this "Godless institution," which three years later would become the first American university to admit women. Cornell then was the largest institution of higher education in America.

Writing in his *History of Cornell*, Morris Bishop said that Ezra Cornell, a devout Quaker, "did not pretend to love all mankind indiscriminately. He despised idlers, weaklings and 'gentleman loafers.' Cornell's great benefaction was designed to give poor, ambitous boys opportunities which would have been precious to himself."

By the turn of the century, nearly 40 percent of all Cornell students were enrolled in the school of civil engineering or in the Sibley School, which included both mechanical and electrical engineering. The great Cornell experiment, scarcely more than three decades old then, had already created pre-eminence in engineering, agriculture and veterinary medicine in a modern university environment. It was to be the model that validated and enhanced the great period of university building associated with the 20th century.

Asa Packer and Lehigh University



Asa Packer

Asa Packer, founder of Lehigh University, was born in Mystic, Conn., in 1805. At the age of 17 he left home to seek his fortune as a self-trained carpenter, walking from Mystic to Susquehanna County, Pa. For 10 years he worked at his trade; he acquired a farm and in 1828 married Sarah M. Blakeslee.

Learning of a need for men to run boats of coal from the great coal fields in the hills and mountains of eastern Pennsylvania, the Packers left their farm in the spring of 1834 and moved to Mauch Chunk, a major shipping town on the new Lehigh Canal, which provided access to tidewater from which coal could be shipped to major coastal centers—especially New York City.

Packer worked briefly as a boatman, using his earnings to acquire several boats of his own. He then bought a boat yard that did much of the contract work involved in building shipping docks in the upper portion of the canal. In time he also invested in the coal mining fields. As waterways and canals gave way to the new transportation wave—railroads, Asa Packer financed the development of the Lehigh Valley Railroad between 1852 and 1855, serving as its president until his death in 1879.

Besides the routine exposure to other entrepreneurs and investors that came with such a prominent business position, Packer was involved in politics. These experiences exposed him to more of life than he might otherwise have experienced living on an isolated farm or at Mauch Chunk. He served in the Pennsylvania House of Representatives from 1843 to 1847, and later was an associate justice of Carbon County (a subdivision of Northampton County, which he helped create while a representative).

From 1853 to 1857 he served in the U.S. House of Representatives, where he was regarded as a "quiet politician." Never in his four years of service did he give a speech. After he founded his university in 1865, he continued his involvement in politics as a candidate for the Democratic nomination for president in 1868. In 1869 he was narrowly defeated in the race for the governorship of Pennsylvania. Three years before he died in 1879, he served as commissioner of the Centennial Exposition of the United States in Philadelphia.

In the fall of 1864 Packer sought out the Episcopal bishop of the Diocese of Pennsylvania, William Bacon Stevens, to discuss the notion of doing something to benefit the residents of his state, especially those from the Lehigh Valley region. Packer realized that some sort of educational institution "for the intellectual and moral improvement of the young men of [that] region" would help accomplish his broad objective.

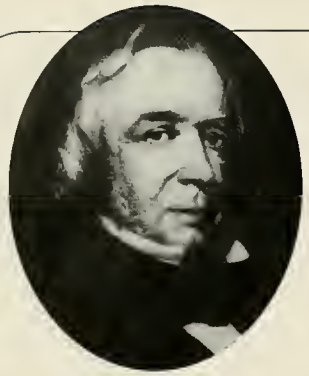
He set aside $500,000 for the university, the largest single sum associated with the founding of a university to that point. Packer asked the bishop to help him devise a plan for his proposed institution.

In choosing a site for his university, Asa Packer first considered Mauch Chunk, at the upper end of the Lehigh Valley, but poor access, rugged topography and a sparse population argued against the location. He discussed the possibility of merging his school with the then 50-student Lafayette College, located at the lower end of the valley in Easton. He finally settled on Bethlehem, where the canal meets the Lehigh River, and where there was a healthy, growing industrial community anchored by the Bethlehem Iron Works (later Bethlehem Steel).

Lehigh University's founding board of trustees—selected by Packer—met for the first time on July 27, 1865, in Bethlehem. Five schools were established: general literature, civil engineering, mechanical engineering, mining and metallurgy, and analytical chemistry.

The influence of Bishop Stevens was reflected in the initial organization of the university. One overarching principle followed by the Lehigh trustees was combining scientific and classical education, as embraced by the early Moravian educator John A. Comenius, and around which a substantial Moravian community had been developed in Bethlehem. Lehigh's motto, *Homo minister et interpres naturae* (man, the servant and interpreter of nature) reflects this principle.

1865



Edwin Stevens

Edwin A. Stevens and Stevens Institute of Technology

Though it was a bequest from Edwin A. Stevens that enabled Stevens Institute of Technology to come into being in 1870, in a real sense the founding of this institution in Hoboken, N.J., was a family affair.

Edwin was the youngest of the six sons of John Stevens, an inventor, a developer of steamboats, a wealthy landowner, and one of the nation's pioneers in mechanical transportation. John Stevens was a 1768 graduate of King's College (now Columbia University), a member of the New York Bar, and treasurer of the state of New Jersey during the Revolutionary War.

Toward the end of the 18th century, a wise man could see that steam power would be the next major stage in the evolution of transportation. Having witnessed John Fitch's experimental steamboat on the Delaware River, Stevens corresponded with Fitch's rival, James Rumsey, suggesting improvements in Rumsey's engine designs. Shortly after, Stevens designed a steam engine with an improved vertical border. To protect his idea he petitioned friends in Washington and helped bring about the first U.S. patent laws; he earned one of the earliest patents, in 1791.

In 1797 John Stevens and a New Jersey foundry operator built a steamboat. Stevens' brother-in-law, New York chancellor Robert Livingston, helped them secure a monopoly for steam transportation on the Hudson River. (Livingston, largely involved for his political talents, later supported Robert Fulton's *Clermont*, which successfully navigated the Hudson from New York City to Albany in 1808.)

Stevens sent his new vessel, the *Phoenix* (largely the work of his son, Robert Livingston Stevens), to a new berth in Philadelphia. It was the first successful ocean voyage by any steamboat. Soon the *Phoenix* was plying the waters between Philadelphia and Trenton.

Desiring to connect his Philadelphia and New York City shipping and transportation interests, Stevens received the rights from the New Jersey legislature to build what was to become the Camden and Amboy Railroad, which ran from Philadelphia to Amboy, just below Staten Island.

In those early days, with no rolling mills available, rails were made of wood or wood thinly plated with scrap iron. While on a long voyage to Liverpool, Stevens' sons Robert and Edwin designed what became the Stevens, or American, rail, now the general form used in the United States.

The brothers saw George Stephenson's early engine in England and in 1831 ordered the *John Bull* for the new Camden and Amboy line. Edwin, who became the railroad's business manager, was also an inventor, creating an improved cast iron plow, a dump wagon used for many years to haul refuse in New York City, and the vestibule railroad passenger car.

Another of the brothers, John Cox Stevens, was the first commodore of the New York Yacht Club. Its early gatherings took place at Castle Point, the Stevens family's estate in Hoboken. It was this brother who designed and built the schooner *America*, which won a startling victory in a race against British yachts—the beginning of the America's Cup race.

Stimulated by the growing hostility between England and the United States over the location of the Canadian-U.S. border, Robert Stevens and his father began work on an ironclad naval vessel. The *Stevens Battery* was 410 feet long and 45 feet wide, with a flat deck designed to ride only two feet above the water line, and was covered with 4 1/2 inches of iron sheet. However, due to the continuing changes in gunnery technology, the vessel was never finished. The elder John Stevens died in 1838 at age 88; his son Robert died in 1856.

After the war Edwin reflected on the dreams his father had had for the founding of an academy of science. Like most entrepreneurs, he had not had much cash to spare, but his son could now translate his dream into reality. In his will he left family land at Castle Point and a $650,000 building and endowment fund to help create the Stevens Institute. After he died in 1868 at the age of 73, the founding trustees decided that the new school would have a single curriculum leading to a baccalaureate degree they designated "Mechanical Engineer."

The first president of Stevens, Henry Morton, had been secretary of the Franklin Institute and editor of its *Journal*. In 1871 he attracted Robert Henry Thurston to Stevens Institute. Thurston was born in Providence into a family of manufacturers. His father, a manufacturer of steam engines, once engaged in a patent dispute with fellow Providence industrialist George H. Corliss, inventor of the Corliss engine, the first great engine of the steam era.

Thurston graduated from Brown University in 1859 and, following service as a Naval officer in the Civil War, began a distinguished career in education. He "invented the idea that a mechanical laboratory is an appropriate part of an American engineering school," according to his biographer, William F. Durand. In 1880 Thurston founded and served as president of the American Society of Mechanical Engineers.

With the hiring of Thurston, the vision of the founders of Stevens Institute to raise the stature of instruction in mechanical engineering education was rapidly achieved.

The Camden terminal on the Camden and Amboy Railroad in 1834.

1870

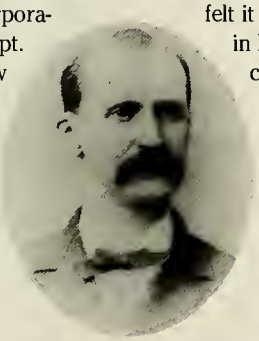
Chauncey Rose and Rose-Hulman Institute of Technology

Chauncey Rose

The founders of many colleges of science and technology were motivated by the need to generate talent for business and industry in regions where that talent was lacking. That was the motivation behind the creation of Rose Institute of Technology in Terre Haute, Ind.

Chauncey Rose, the leading businessman in his community, had had great difficulty getting young men with technical training to come "so far west" to help design and oversee the construction of railroad lines to link Indiana with the rest of the nation.

In 1874 he asked two friends, William A. Jones and Charles R. Peddle, to visit several technical schools in the East to search for a model for the college they hoped to create. They settled on WPI, which was then just 8 years old. Rose, Jones, Peddle and other carefully selected men organized a corporation that received its charter on Sept. 10, 1874. They named their new college Terre Haute School of Industrial Science, a nod to the school's model, then known as Worcester County Free Institute of Industrial Science. Rose gave 10 acres of land and $186,000 to get the school started.



Charles O. Thompson

A lifetime bachelor, Rose outlived his six brothers and one sister. Upon his death in 1877, the college would receive another $105,000 plus his residuary estate. Overall, his contributions would total nearly $500,000.

Rose was a generous man. When his mother died he gave the family homestead in Wethersfield, Conn., to the community along with $3,000 to improve it. He also gave $2,000 to the library and $1,200 to endow an academy in Wethersfield. Among the institutions he aided in his adopted community of Terre Haute were Providence Hospital, the Ladies Aid Society (widows and dependents of soldiers from the Civil War), the Orphans' Home and Indiana State Normal School.

In 1817, at the age of 22, Rose set out to seek his fortune in the West armed with $2,000 borrowed from his brother George. He settled at first in a tiny village in Parke County, Ind., that would eventually be named Roseville in his honor. With business associates, he formed a mill, a distillery and a store.

With the early profits from these businesses and $8,000 he had inherited from his brother's estate in 1825, he purchased 320 acres of land in the early 1830s in what was to become the region's largest community, Terre Haute.

For communities to develop, Rose knew they needed easy and dependable transportation. So he became involved with the financing and building of railroads. With the help of a wealthy brother, John, in New York City, who sold stock for his ventures, Rose created several railroads, including the Wabash and Erie line.

On Sept. 11, 1875, the cornerstone of the main building of Rose's new school was laid. The board of managers voted that day to change the name of the college to Rose Polytechnic Institute. By early 1882 the board felt it had sufficient operating funds in hand to open the institute. It chose as its president Charles O. Thompson, then principal of WPI. Thompson, WPI's first executive officer, agreed to undertake another inaugural presidency only after he was granted a generous financial package that included a year to visit and study technological schools in Europe.

A bright and shrewd Connecticut Yankee, Thompson was born in 1836 in East Windsor, Conn., about 15 miles from Chauncey Rose's birthplace. His father was a professor at the Connecticut Theological Seminary, and the young Thompson attended East Windsor Academy and graduated from Dartmouth in 1858. For six years he served as principal at Peacham Academy in Vermont. During that period he earned his M.A. from Dartmouth.

In 1865 he was attracted to Arlington, Mass., where he served a little over three years, converting the old Cotting Academy to the Cotting Public High School, before being named principal of WPI. Two years later he received his doctorate from Dartmouth.

Thompson's tenure at Rose was brief; he died on March 17, 1885. Adding to the ties between Rose and WPI, Thompson was succeeded by Thomas C. Mendenhall, who served about three years before accepting the post of Superintendent of the U.S. Coast and Geodetic Survey in 1889. Five years later, Mendenhall went on to become WPI's third president.

In 1917 the Hulman family donated a 123-acre farm to the institute and the campus was soon moved there. In 1970, nearly a century after the founding of Rose Polytechnic Institute, Mr. and Mrs. Anton Hulman Jr. transferred all of the assets of the Hulman Foundation to the college. The assets were conservatively appraised at $11 million, making the gift nearly equal to the value of the school's endowment and physical plant at that time. The college's name was changed to Rose-Hulman Institute of Technology. Thus, in a real sense, Rose was "refounded" nearly a century after its founding days.

The original main building on the Rose Polytechnic campus.

1874

Leland Stanford

Leland and Jane Stanford and Stanford University

Stanford University was created as a living memorial. Founded by Leland and Jane Stanford, the university honors the memory of their only child, Leland Stanford Jr., who died at a young age.

The senior Stanford was born in Watervliet Township, N.Y., in 1824, the year Rensselaer Polytechnic Institute, the nation's oldest technological institution, was founded in nearby Troy. Stanford's father, a farmer, woodcutter and occasional innkeeper, chose Leland as the son who would follow a professional career. After working for three years in an Albany law firm, Leland was admitted to the bar in 1848 and set off for Port Washington, Wisc., to set up his practice.

In 1850 he returned to Albany to marry Jane Eliza Lathrop, daughter of a successful Albany merchant. A fire destroyed his office and library in Port Washington two years later. He sent Jane back to New York and joined his five brothers in a merchant business in the mother lode country of California. In 1855, when he took charge of the company's main store in Sacramento, he brought Jane west.

Stanford was a leader in the formation of the Republican Party in California, and was the new party's unsuccessful candidate for state treasurer in 1857 and for governor in 1859. He won the race for the governorship in 1861, and in that post helped keep California in the Union and led a drive to help supply the North during the Civil War.

After the war he joined with three other Sacramento merchants to build the Central Pacific Railroad, the western link of the first transcontinental railroad. As president of Central Pacific, Stanford drove home the gold spike at Promontory Point, Utah, that symbolically linked the nation's coastlines.

Leland Stanford Jr. was born in 1868. By then the Stanfords owned a mansion on San Francisco's Nob Hill, but, wanting their son to spend time out-of-doors, they purchased a 650-acre farm 30 miles south of the city where they built a country home. They continued to add to the Palo Alto Farm over time until it spanned more than 8,000 acres.

Tragedy struck on a trip abroad. In Athens young Stanford persisted in collecting artifacts despite the foul winter weather, and later complained of a headache and sore throat. The family pushed on to Florence, where the son died from typhoid fever on March 13, 1884, two months short of his 16th birthday. After a long, sleepless night, Leland and Jane resolved to realize their long-held plan for using part of their wealth for public benefaction, saying "the children of California shall be our children."

The Stanfords visited Charles Eliot, president of Harvard, to gain his reaction to this idea. Eliot favored the notion of creating a university that would include among its curricula the study of civil and mechanical engineering. They later conferred with the presidents of Cornell, MIT and Johns Hopkins.

Stanford was elected to the U.S. Senate in 1885, and returned to his farm the following summer to work out plans for the campus with Francis A. Walker, president of MIT, and Frederick Law Olmstead, designer of New York's Central Park. (Olmstead's associate, Calvert Vaux, designed WPI's initial campus grounds.)

The Leland Stanford Jr. University, as it is officially known, was formally created in a ceremony in the library of the Stanfords' San Francisco home on Nov. 14, 1885. Its buildings were designed by Charles Allerton Coolidge of Boston, then at the beginning of a distinguished career. (The successor to his firm, today known as Shepley, Bulfinch, Richardson and Abbot, is the architect for the current refurbishment of WPI's Alden Memorial Auditorium.)

The cornerstone of Stanford was laid on May 14, 1887, which would have been Leland Jr.'s 19th birthday, and 465 students had enrolled by opening day, October 1, 1891. Presiding over the university was 40-year-old David Starr Jordan, previously Indiana University's president, hired on the recommendation of Cornell's president, Andrew D. White. At a ceremony that day Leland Stanford offered these remarks: "This ceremony marks an epoch in our lives, for we see in part the realization of the hopes and efforts of years; for you, the faculty and students, the work begins now."

Unlike many other founders, the Stanfords took an active role in the physical development of their university, though they left its academic plan in the hands of President Jordan, who found it challenging at first to attract established Eastern scholars to Stanford. "In the Back Bay," he once said, "are men whom nothing would induce

The Stanford home at Palo Alto Farm, the property that would become the site of the Stanford campus.

1885

Jane Stanford and Leland Jr.

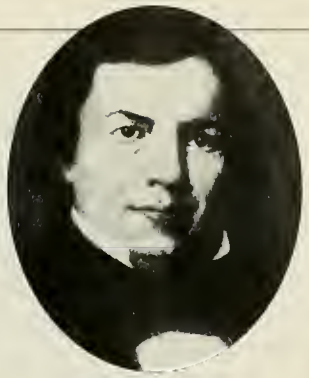
to go west of Springfield."

Leland Stanford died on June 21, 1893, a few days after he attended Stanford's annual commencement and a few years after his re-election to the Senate. His wife vigorously continued work on the campus as the nation endured six years of hardship following a financial panic in 1893.

A claim against her husband's estate by the federal government was settled in the Stanfords' favor by the Supreme Court in 1896. The following year Jane Stanford turned over $11 million to the university, which helped speed the construction of additional facilities. Mrs. Stanford oversaw this work with great care until her death in 1905. Just over a year later, at 5:13 a.m. on April 18, 1906, the great earthquake struck, causing nearly $2.5 million in damage to the young campus.

The Stanfords left an enduring legacy, including a major endowment and 8,500 acres of land they decreed could never be sold, but used only for the betterment of their institution. The Stanford Industrial Park, which today occupies part of that land, has played a major role in making Stanford one of the nation's pre-eminent universities in science and technology.

William Marsh Rice and Rice University



William Marsh Rice

The founding of Rice University had the makings of a classic mystery novel, complete with deception, a false will and a murder (yes, the butler did it). But we're getting ahead of the story.

William Marsh Rice was born in Springfield, Mass., in 1816. His father spent many years working in the Watershops division (forging shops) of the Federal Arsenal at Springfield, one of the nation's oldest settlements. The elder Rice, who was a trustee of Wesleyan Academy (now Wilbraham-Monson Academy) in nearby Wilbraham (your author's hometown), had a keen interest in education. And William, himself, sent two of his 10 siblings (several did not survive childhood) to the academy, and later provided a Princeton education to his nephew and namesake, William Marsh Rice II.

Rice left school at 15 to work as a clerk in a grocery store and eventually bought a store of his own. In the 1830s, as the U.S. entered a long period of depression, promoters for the railroad and barge industries began urging people to go West to help develop new communities. Their entreaties attracted Rice.

Houston, in what was then the Republic of Texas, was a tent city when Rice arrived in 1837. A teetotaler himself, he signed an agreement to furnish liquor to a hotel. From that simple beginning he formed a series of successive partnerships in wholesaling, bringing goods in from New Orleans for settlers and plantation owners. But it was the Texas goods—especially baled cotton—that Rice shipped east from Galveston that made his fortune.

In 1863 his wife of 13 years died. The loss and the ongoing Civil War set Rice to wandering through Mexico for more than 18 months. He returned to Houston in late 1865, but because he was suspected of having Northern sympathies, found it more prudent to carry on his post-war business through agents. In 1867 he married his sister-in-law, Elizabeth Baldwin Brown. The couple lived part of the year in Houston and part in a succession of New York City apartments, after 11 years of living on a gentleman's farm in Dunellin, N.J.

Rice's second wife, Elizabeth Baldwin Brown.

As he approached the end of his life, Rice, who, having served on the boards of several Houston educational organizations, knew well the poor state of education in the city, focused his efforts on founding an educational institution. He was drawn to the example of Stephen Girard, a French ship owner who left $6 million to create a school for orphans in his adopted Philadelphia. Rice for a time considered founding a similar school on his New Jersey farm.

Cesar Maurice Lombardi, a native of Switzerland who was then president of the Houston school board, suggested that Rice found a high school in Houston. Though Rice rejected the notion, it did help turn his thinking to his adopted city. Having been influenced by the educational model of the Cooper Union (page 4) during his summer stays in New York City, he settled upon the idea of founding the William Rice Institute of Literature, Science and Art in Houston.

Among the trustees he chose for the new institute was attorney James A. Baker Jr., grandfather of Secretary of State James A. Baker III. Secured by a $200,000 note from Rice (Rice also deeded extensive real estate holdings to the institute), the school was formally incorporated in Austin on May 19, 1891. Its charter said it would be a free polytechnic school for men and women, "designed to give instructions on the application of Science and Art to the useful occupations of life."

Here the plot thickens. Elizabeth Rice had a partial stroke in 1896. An ambitious local lawyer, Orrin Holt, got her to secretly sign a new will that made her a resident of Harris County, Texas. Under

1891

Texas law, half of her husband's assets belonged to her. The will would have left some of her half to relatives and to a home for indigent women in Baldwinsville, N.Y., (named for her family), with the rest creating a Baldwin park in Houston and paying for portraits of her husband and her aunt for the institute library.

The Rices traveled to a recuperative spa in Wisconsin, where she died after suffering two additional strokes. In short order Rice received the astounding news that his wife's will had been filed for probate in Texas. Eventually, James Baker proved that the Rices were, in fact, New York City residents. Indeed, it was said that Baker almost singlehandedly saved Rice Institute.

Now that he was alone, Rice needed a servant to provide for his needs. In 1896 he hired a young Houstonian, Charlie Jones, the 21-year-old son of a tenant farmer. Meanwhile, Orrin Holt hired New York City lawyer Albert T. Patrick, a transplanted Texan, to gather information establishing Elizabeth

Rice's killer, Charlie Jones.

Rice's Texas residency. Patrick made Jones' acquaintance, and, after practicing Rice's signature, created a new will that left the Institute only $200,000.

Patrick suggested to Jones that "Rice is living too long for our interests." In September Jones placed a cone laced with chloroform over the nose and mouth of the sleeping Rice. Patrick and Jones immediately tried to arrange for a cremation, but Baker insisted that an autopsy be performed. When the Patrick will surfaced, the signature proved a forgery and Patrick and Jones were arrested.

Jones was later allowed to return to Texas, where he shot himself in 1954. Patrick had his death sentence commuted. He was later pardoned and spent the rest of his days as an itinerant auto salesman in Oklahoma, where he died in 1940.

When the dust settled and the Rice will of 1896 was sustained, Rice Institute received well over $4 million. Some 77 students began their studies in September 1912 on a campus designed by noted Boston architect Ralph Adams Cram. On the recommendation of Woodrow Wilson, then president of Princeton, the distinguished Princeton faculty member Edgar Odell Lovett became Rice's first president.

Today a visitor can admire the bronze statue of Rice in the heart of the quadrangle of the university campus. On the pedestal, which is graced with a seal of the Commonwealth of Massachusetts, is the Massachusetts motto, which seems especially appropriate: Ense Petite Placidam Sub Libertate Quietam (with the sword, she seeks quiet peace under liberty).

Mildred and Henry Mudd and Harvey Mudd College

Harvey Mudd College is one of the few private engineering and science colleges established during the 20th century. Located in Claremont, Calif., it is one of the Claremont Colleges, a well-known group of associated colleges that includes Pomona, Scripps, Pitzer, Claremont-McKenna and the Claremont Graduate School.

Each of the Claremont Colleges is an autonomous institution with its own board of trustees, but together they share common academic and support services, including physical plant management, athletic facilities and a central library. Though each college has a distinct identity, including a unique architectural idiom that helps convey the spirit of a small institution, as a group they have the "feel" of a moderate-size university.

The Mudd name is intimately linked to the family's famous mining company, Cyprus Mines, and to its long-standing support of higher education. Through his own foundation, Seeley W. Mudd, the first of the three generations of Mudds to control Cyprus Mines, gave science and technology buildings to several colleges around the United States. Harvey Mudd College, named for Seeley's son, was founded in 1955 by Harvey's wife, Mildred, and his son, Henry.

Henry Mudd, founder, with his mother, of the college named for his father.

While small in enrollment (it currently has 550 undergraduates) and quite young compared to its peer colleges, Harvey Mudd is among the nation's most selective private colleges of science and engineering. It ranks first in the nation in the proportion of its alumni who earn Ph.D.s in engineering (WPI is ranked third).

When Mildred Mudd died in 1957, her son became the driving force behind the developing college. A Los Angeles native who earned a bachelor's degree in geology at Stanford and a master's in mining engineering at MIT, Henry Mudd served as chairman of the board of trustees from 1958 to 1981, helping to shape a philosophy of education for Harvey Mudd that is remarkably parallel to that of the WPI Plan.

In 1981, in honor of his "contribution to humanity through the dissemination of knowledge and his generous philanthropic gifts and activities," he was made an honorary member of the American Institute of Mining, Metallurgical and Petroleum Engineers.

A Westerner, well-educated for his time, and an engineer from a distinguished American mining family, Henry Mudd lived a life quite different from those of so many of the founders of the engineering institutions that emerged in the 19th century. His "advantages" contributed to the distinctive and distinguishing features of Harvey Mudd College.

Andrew Carnegie and Carnegie-Mellon University

Andrew Carnegie

Among founders of the nation's colleges and universities, Andrew Carnegie is, perhaps, the best known. At the age of 13, he came to Allegheny, Pa., from Scotland with his father, mother and brother. More than 50 years later, when he founded the Carnegie Technical Schools in Pittsburgh, he was considered the richest person in the nation. While he made his mark as a tough, driving businessman, he is far better remembered for the magnitude and the quality of his philanthropy.

During the Gilded Age that incubated the Rockefellers, the Morgans, the Harrimans, the Vanderbilts and the other "Robber Barons," *North American Review* published "The Gospel of Wealth," a seminal paper on philanthropy that Carnegie, then 54, had written years earlier. It was filled with pithy aphorisms, such as "the man who dies rich dies disgraced." A millionaire's fortune, he said, is not his creation, but that of society as a whole, to which a proper sense of honesty demanded that it be returned in ways that would improve the lot of the common man.

Carnegie practiced what he preached. During his lifetime he donated 2,811 libraries throughout the English-speaking world and gave 7,689 organs to churches. He built New York City's Carnegie Hall (celebrating its centennial this year), Carnegie Music Hall in Pittsburgh, and three monuments to peace—the Pan American Union Building in Washington, D.C., the Central America Court of Justice in Costa Rica, and the Temple of Peace in the Netherlands.

In 1900 he founded the Carnegie Schools in Pittsburgh. Originally a nondegree trade school that cost students $20 a year, it grew into Carnegie-Mellon University. His total lifetime philanthropic giving for charitable aims was $325 million.

Skibo Castle, Carnegie's Scottish retreat.

Andrew Carnegie began work as a bobbin boy shortly after his family arrived from Scotland. He learned telegraphy and joined the Pennsylvania Railroad as a telegraph operator in 1853, two years before his father's death; by 1859 he was a division superintendent. In the meantime he was shrewdly at work investing his earnings, so that by 1863 he was making $48,000 a year, even though the railroad job paid only $2,400.

He left the railroad in 1868 and formed a number of companies. He also bought an iron mill, and in 1872 acquired the American rights to the British Bessemer process that removes impurities from iron ore to produce high-grade steel. This investment was the key to his subsequent wealth.

The Carnegie Brothers Steel Works was ready for business in 1875. Carnegie hired Capt. Bill Jones to be the plant's superintendent. In modern parlance, Jones was a practical genius who applied his skills to improving the steel-making process and machinery.

Feeding the nation's insatiable demand for steel rails and girders, the company grew rapidly. With Jones' skills and Carnegie's ability to find and motivate talent, it successfully beat the competition on price. In 1889 Jones was killed when a furnace he was repairing exploded.

Only petroleum magnate John D. Rockefeller's success rivaled Carnegie's in his heyday. Like Rockefeller, Carnegie integrated his business by buying out the largest coke supplier in the Pittsburgh region, the H.C. Frick Coke Co. With the acquisition, Carnegie gained the managerial talent of Henry Clay Frick, who helped acquire iron mines, ore-carrying ships and railroads to bring raw material to the Carnegie furnaces and rolling mills. (Incidentally, Frick's mansion on Fifth Avenue in New York City is now the Frick Museum; Carnegie's mansion, further up on Fifth Avenue, houses the Cooper-Hewitt Museum of Design of the Smithsonian Institution.)

By 1899 Carnegie was responsible for 70 percent of the nation's steel exports, but change was on the horizon. Led by financier J.P. Morgan, the scattered makers of nails, wire, tubes, pipes, boiler plate and other steel products, who had formerly bought their raw materials from Carnegie, were being integrated into trusts. Carnegie decided to begin making finished products himself, but was attacked by his major shipper, the Pennsylvania Railroad, which doubled its freight rate from Pittsburgh to the seaboard.

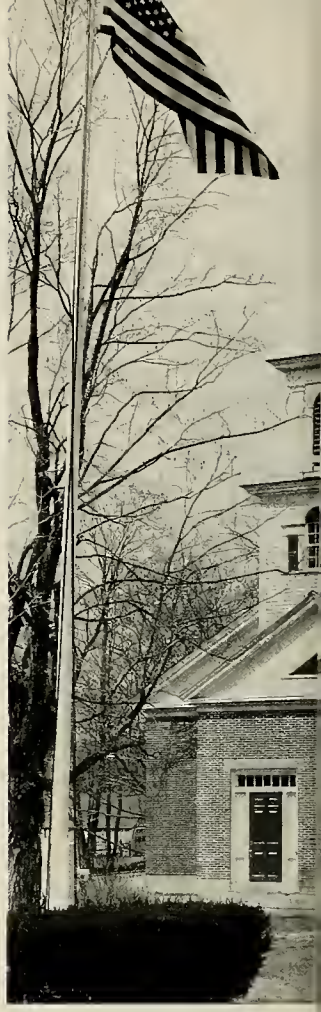
At a New York City party in late 1890 attended by most of the major steel barons, a dialog began between Carnegie and Morgan interests. Seeing the benefits of creating one giant industry, rather than two large ones continually at odds, Morgan and Carnegie in January 1901 created a billion dollar conglomerate that later became the United States Steel Corp. Carnegie's share of the sale was $480 million.

While Carnegie had been a driven man, he was very much the booster and marketer of a more modern age. He flattered others when purposes suited him, and personally obtained many of the major steel contracts, some from as far afield as the Russian government, to whom he supplied plate steel for naval vessels.

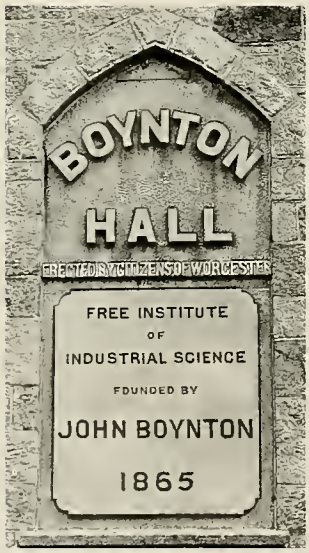
The balance of his life after the sale of his corporation was spent creating and managing his prolific and wise philanthropic interests. He spent many summers with his mother at Skibo Castle, his Scottish retreat in Dornoch (the town where noted golf course architect Donald Ross first developed an interest in golf architecture). It wasn't until after his mother's death that he married Louise Whitfield, whom he had courted for seven years (nearly always with his mother being present).

Carnegie died on Aug. 11, 1919, at Shadowbrook, his summer home in Lenox, Mass. He was buried in Sleepy Hollow Cemetery in North Tarrytown, N.Y., his grave marked with a Celtic cross cut from stone quarried near his beloved Skibo Castle. The respect he had for education, having virtually none of his own, made of this 5-foot-3-inch man a modern-day giant.

1900



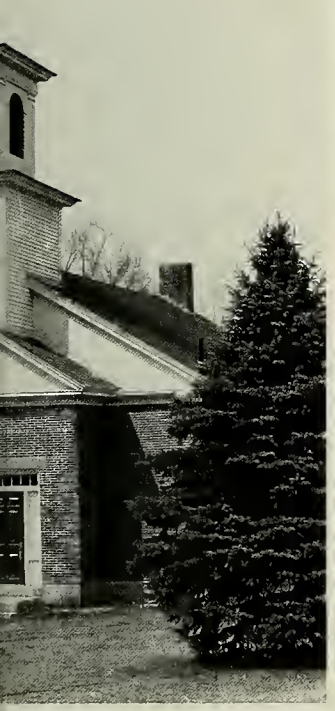
John Boynton's Legacy

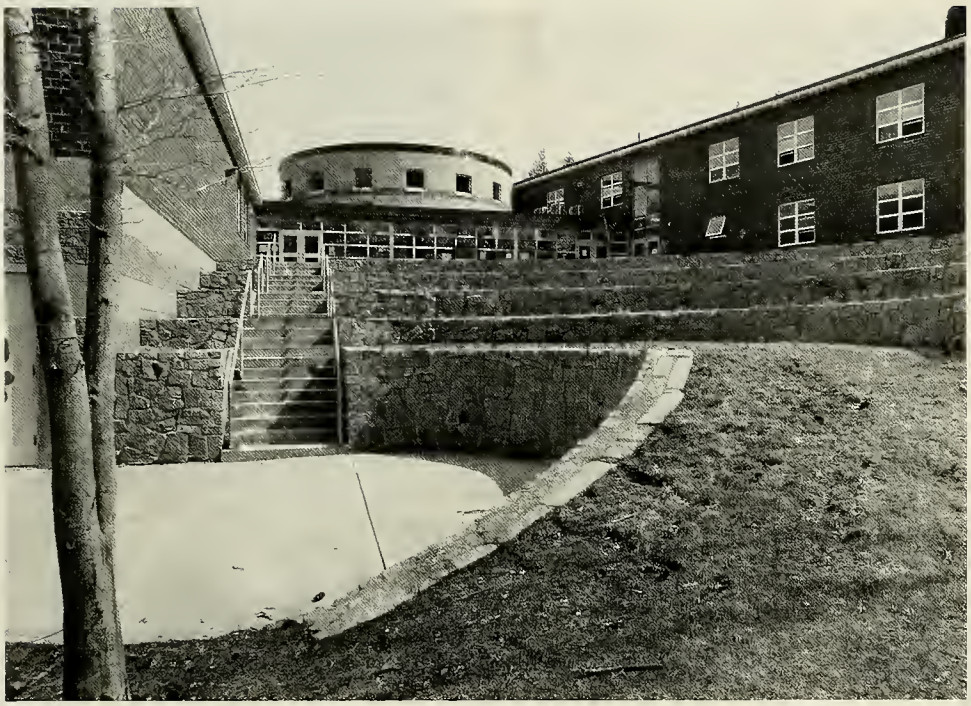


Leaving behind the traffic and bustle of Fitchburg, Mass., the highway climbs gently through the woods and farms of southern New Hampshire. After a few miles, the road narrows and the houses and barns seem few and far between. At the final turn a stone marker points the way up a long, steep hill. Near the top one passes a small country cemetery, a simple, white clapboard church and a weathered stone monument. Ahead rises the steeple of the old Christian Church, now the town's elementary school.

This is Mason, N.H., birthplace of WPI's founder, John Boynton. It was on his family's farm a few miles outside of Mason center that Boynton was born 200 years ago, on May 31, 1791, a descendant of a distinguished English family. The first Boynton to arrive in the New World settled in Rowley, Mass., in 1638. More than 150 years later, John Boynton's father, Jeremiah, was eking out a living from the rocky New England soil.

In Boynton's day poor farm boys had little time for formal schooling. Boynton attended the No. 2 school house near Pratt Pond in Mason a few weeks in the winter and a few weeks in the summer. He was taught the rudi-





PHOTOS BY JANET WOODCOCK

# of Hope and Opportunity

By Michael Dorsey

ments of reading, writing and ciphering. When he could "cipher to the rule of 3," notes town historian Elizabeth Horton Jones in Mason's centennial history, it was time to devote all of his energies to farm chores.

But Boynton's ambitions lay beyond his father's fields. When he turned 30, he set out from Mason to the adjacent town of New Ipswich to learn the craft of tin making. In the early 19th century the American Industrial Revolution was about to hit its stride, but there was still good money to be made handcrafting products for the mass consumer market.

One of the most lucrative of these more traditional trades was tin making. While the average household used porcelain crocks for cooking and storing food, tinware was beginning to gain popularity. In fact, several other tin manufacturers were already established in southern New Hampshire when Boynton started his company in 1821.

Using an anvil, a hammer and a variety of templates, Boynton stamped out plain tinplate pots and pans, coffee pots, sugar bowls and other everyday implements. Boynton hand decorated many of the items, some with a hard, dark varnish called japan. Boynton's japanware is much prized today by collectors.

Above, from left, the Boynton Public Library in Templeton, Mass., a gift of Boynton's cousin, David Whitcomb; the Mason (N.H.) Elementary School, which Boynton supported with a $10,000 gift; the new Boynton Middle School in New Ipswich, N.H.

Left, top, the monument to Boynton erected by the Class of 1922. Left, bottom, one of Boynton's factories in Templeton, today the town's Grange Hall. Center, Boynton Hall at WPI, built with contributions from a number of Worcester citizens.

ALL PHOTOS BUT CENTER, JANET WOODCOCK

At first Boynton peddled his finished products on foot or on horseback. Eventually he was able to hire peddlers who set out across the countryside from Canada to New York in bright red horse-drawn wagons, bartering the tinware for foodstuffs and other goods. The goods were then sold in Boston, the proceeds being used to buy supplies and raw material for the business. A great deal of tinware was exchanged for rags and used paper, which was sold for a healthy return to paper mills. Boynton's peddlers also sold brushes, mops, hoes, shovels, rakes and other tools, as well as peppermint sticks for the children.

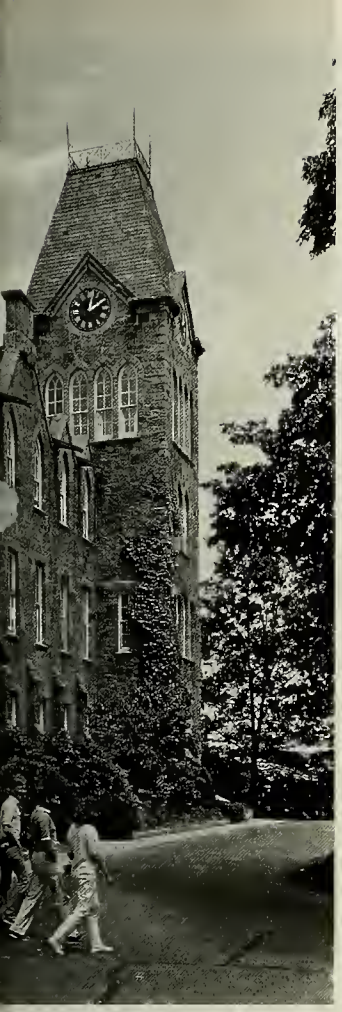
In 1825 Boynton moved his business about 21 miles south to Templeton, Mass. It was the earliest documented tin shop in Worcester County. He set up two factories in the town, one to stamp out the tinware and the other to decorate it. The price of tin products had dropped significantly and demand for the durable and attractive household goods (which included tubs, buckets, milk pails, boxes, candlesticks, trunks, tools and toys) had grown dramatically. Boynton was becoming a wealthy man with enough spare cash to lend money to area towns and to the state.

Two decades after he moved to Templeton, Boynton sold his interest in the business to his cousin, David Whitcomb, and retired. His 20 employees were stamping out $20,000 worth of tinware a year, which, in turn, was sold by about 25 peddlers. Whitcomb, who hailed from Hancock, N.H., not far from Mason, had worked for Boynton since he was 21. He would later sell the tin business and become a prominent businessman in Worcester.

Boynton was 55 when he retired. He'd become one of Templeton's most distinguished and wealthy citizens. He had served briefly as the town's postmaster and had represented Templeton in the state legislature. Dressed in his usual starched shirt, fan waistcoat, vest, and blue outer coat adorned with a solid gold pocket watch, Boynton was a well-known figure on his walks through town. His Greek Revival home was one of the most prominent on the town common.

In the 1860s, having served for several years as the first president of the Millers River Bank in Athol, about nine miles west of Templeton, Boynton resolved to use his modest fortune to help others avoid the hard life he had known as a young man. Recalling the poorly equipped school where he had spent precious few days, he gave $10,000 to Mason in 1865 to establish the Boynton Common School Fund. The money helped buy books and supplies for the Mason Elementary School.

Since those days, two additions have been built onto the small schoolhouse to serve the needs of a growing town, but the Boynton fund still helps purchase materials for the school's students. Interest from the fund is also used by the Masenic School District, which consists of Mason, New Ipswich and Greenville. In 1987, $7,000 from the fund helped the district receive



ROBERT S. ARNOLD

Right, top, the marker for the graves of Abigail and John Boynton in Mason's Pleasant View Cemetery. Right, bottom, Boynton's Greek Revival home in Templeton.

a matching grant from the state to buy computers.

Having had no children and having outlived his wife, Abigail, Boynton chose to use the bulk of his estate—$100,000—to create an educational institution. At the time, most of the nation's colleges taught the classics to future clergymen, teachers, doctors and lawyers. Boynton wanted to create a school where craftsmen, mechanics, farmers and others of the professional and working classes could receive a practical education—the kind he'd never had. A history of Templeton printed during its 225th anniversary in 1987 suggests that Boynton had a dream one night about a great building in the town bearing a sign that read, "School of Technology."

In fact, Boynton did consider placing his new college in Templeton, but was talked out of the idea by David Whitcomb, who knew that the growing industrial city of Worcester would be a more logical choice. The decision may also have been motivated by the cool reception the idea received in Templeton, where most residents believed the time-honored apprenticeship system was the best way to train new craftsmen and mechanics.

In early May 1865, the details of the school having been worked out, Boynton turned his $100,000 over to the trustees of the Worcester County Free Institute of Industrial Science, and on May 10 the college received its charter from the commonwealth of Massachusetts. But Boynton did not live to see his dream fulfilled. In March 1867, during a snowy sleigh ride home to Templeton, he caught pneumonia and died soon thereafter. Back in Worcester, construction on the college's first building was well under way. Boynton Hall was dedicated on Nov. 11, 1868.

John Boynton was buried next to his wife in the Pleasant View Cemetery in Mason. In 1868, the year classes began at WPI, David Whitcomb donated $4,000 to Templeton to buy books for a future public library to be named for Boynton. He gave an additional $4,000 a few years later and the town allocated $2,000 to construct a library building. The Boynton Public Library is still in use just a few doors down from Boynton's house.

Nearly 125 years after his death, Boynton is still remembered in the county where he was born. As a fitting tribute to a man who held education and the future of the youth of the region so dear, the Masenic School District in 1989 voted to name its new middle school for Boynton. The modern school building serves more than 400 students from the district. Across from the principal's office is a bulletin board that proudly proclaims the school the "Home of the Boynton Bulldogs."

The simplest, and perhaps the most elegant tribute to Boynton was established by WPI's Class of 1922 on the occasion of its fifth Reunion. The class gathered the necessary funds to erect a simple monument—a bronze plaque attached to a chunk of native granite—that now greets visitors to the center of Mason. Beneath a concise summary of Boynton's life and death is a simple but appropriate motto: "He Opened the Door of Opportunity to Youth."

PHOTOS BY JANET WOODCOCK

As I Lay Dying: *The Opera*

By Michael Dorsey

How music professor David McKay and English professor Laura Menides translated William Faulkner's classic story of love, death, seduction and survival from the page to the stage.

As a warm front nudges the temperature past the 80 degree mark, making this early April afternoon in New England feel more like a spring day in Mississippi, a small group of singers arrange themselves at music stands in the parlor of a stately farmhouse in Shrewsbury, Mass. Seated at the keyboard of an upright piano, an energetic, grey-haired man addresses the performers in a voice that still bears the distinct mark of his youth in the Deep South.

"Let's take it from the beginning of the Gramophone Masque," he says as the singers find their places and adjust their scores. In a moment their voices fill the room with a haunting jazz melody. "When we stopped we heard the music. A little music," the lyrics say. "I don't know if a little music ain't about the nicest thing a fellow can hear."

Fans of American literature might recognize the words as William Faulkner's, taken from the last pages of his novel *As I Lay Dying*. The composition is the concluding scene of a three-act opera based on the Faulkner work and is written by composer David P. McKay, professor of music at WPI, and librettist Laura Jehn Menides, associate professor of English. The first extended musical work to be based on a Faulkner novel, the opera was commissioned in 1985 by the Center for the Study of Southern Culture.

A complex, difficult novel, *As I Lay Dying* is constructed out of the thoughts, remembrances and feelings of its 15 characters. In a series of internal monologues, the characters tell of an event-filled journey through the back country of Mississippi to bury Addie Bundren, the wife of a poor dirt farmer.

In a style typical of Faulkner's novels, the story is told in a convoluted manner that forces the reader to focus on the complexities of the characters' relationships to one another, rather than on the simple narrative line of the journey itself. With its emphasis on emotion and introspection rather than action, it would seem unlikely source material for a work designed for the stage.

In fact, though, as McKay once told a reporter for the *Jackson (Miss.) Daily News*, the book lends itself almost perfectly to opera. "It reads like an opera scenario," he said. "It has all the elements of grand opera—a journey, a flood, a fire, comedy, insanity, and a sense of survival that finally prevails. I thought it would be marvelous as an opera."

Now, more than six years after work began on the adaptation of *As I Lay Dying*, McKay's assessment is about to be put to the test. Since January a small company of singers and musicians has been meeting once a month to rehearse the opera at McKay's home, preparing for a performance on July 28 at the 18th International Faulkner Conference in Faulkner's hometown of Oxford, Miss., the largest gathering of Faulkner scholars in the world.

As I Lay Dying was published in 1930, when William Faulkner was 33. It had been six years since his first book, *The Marble Faun*, a collection of poems, had appeared, and it would be another 19 years before he received the Nobel Prize for literature. It was the third Faulkner novel set in the fictional Mississippi county of Yoknapatawpha. The first two, *Sartoris* and *The Sound and the Fury*, were published in 1929; *Sanctuary* and *Light in August* followed in 1931 and 1932, respectively.

Faulkner would later claim that in writing *As I Lay Dying*, he deliberately set out to create a tour de force. "Before I began," he explained, "I said, 'I am going to write a book by which, in a pinch, I can stand if I never touch ink again.'" But, accustomed to the lean, direct prose of Hemingway, whose *Farewell to Arms* had been published in 1929, some reviewers found Faulkner's verbose, obscure style tough going; a few rejected his work as bad writing. Still, *As I Lay Dying* won general critical acclaim and has remained one of Faulkner's most popular novels.

"I really like this book," says Menides, who studied the novel extensively while working toward her master's degree at the University of Chicago and her Ph.D. at New York University. "I teach it often in my classes at WPI. It's a difficult book for students, but once they get into it they really enjoy it—especially the men, who identify with the brothers Jewel and Darl. They often write fascinating papers on sibling rivalry, on the withholding of love on the part of a mother and what that does to a child, and on children's love for animals. Faulkner really knew what he was talking about."

Librettist Laura Menides took on the daunting task of rearranging and transforming Faulkner's complex story into a linear narrative line.

The central character of *As I Lay Dying* is Addie Bundren, near death as the story begins. Her husband, Anse, who calls himself a "luckless man" but is in reality a lazy, ambitionless farmer with the mysterious power to get others to do his work, is preparing to fulfill Addie's wish to be buried 40 miles away in the town of Jefferson. As Cash, the firstborn son, builds Addie's coffin, the other children, speaking directly to the reader, reveal the intricacies of their relationship to one another and their reactions to Addie's impending demise.

We learn about the conflict between Jewel, the son born of an affair between Addie and the Rev. Whitfield, and Darl, Addie's least-loved child who has an almost empathic awareness of the thoughts and feelings of others. Darl's unspoken knowledge of the pregnancy of his sister, Dewey Dell, is a source of tension between these two siblings. We also learn of the confusion felt by the youngest child, Vardaman, over the imminent death of Addie, which Faulkner sums up by having Vardaman compare his mother to a fish that was alive when he caught it but that now lies dead on the ground.

Addie dies and the Rev. Whitfield conducts her funeral. Members of her family speak about what they hope to gain on the trip to Jefferson. His main goal is to bury his mother, but Cash would also like to buy a gramophone. Anse wants a new set of false teeth. Dewey Dell wants medicine to end her pregnancy. And Vardaman yearns to see a toy train in a store window.

The journey is hindered by a flood, which washes out the bridges to Jefferson. The Bundrens ford the swollen river with their wagon, nearly losing the coffin in the rushing water. After they've been on the road for several days, the family stops to sleep at a farm and Darl sets fire to the barn that shelters his mother's coffin—now attracting an ever-increasing flock of buzzards. Jewel, as the dying Addie had predicted, saves his mother from the flood and the fire.

Eight days after the start of the journey, the coffin is finally put into the ground in Jefferson. To avoid a lawsuit, Anse has Darl committed to an insane asylum. Dewey Dell tries to buy her abortion medicine, but is instead seduced by a pharmacy clerk. Anse buys his teeth with the money Dewey Dell had saved for the medicine and, as the novel ends, announces he will marry the woman from whom he borrowed the shovels to bury Addie. The woman, to the delight of Cash, owns a gramophone.

"In a wonderful bit of comic hyperbole, the woman who lends them the shovels to bury wife number one, becomes wife number two," McKay says. "That's perfect Faulkner. He always puts the impossible into the improbable into the real."

While the book's narrative may seem simple, it is complicated substantially in the way Faulkner tells it. Critics have noted that Faulkner's novels rarely follow a formal chronological story line, but present the reader with a story that more closely resembles a set of overlapping circles. "The chronology may be reconstructed after the fact," Dorothy Tuck noted in *Crowell's Handbook of Faulkner*, "but piecing together the events can convey only the facts of the story, not its essence as a recreation of life that Faulkner has given it."

Faulkner's writing style has often been compared to poetry; in fact, Faulkner began his writing career as a poet. In his stories meaning is "deliberately withheld," in Tuck's words, and the reader is challenged to extract the themes and ideas from a lush tapestry of emotions, paradoxes, oxymorons and scenes that border on the grotesque and surreal. The goal, like that of a poet's, Tuck notes, is to keep the basic idea unclear until the last syllable on the last page.

Clearly, bringing such a complex work to the stage would be a challenging task. "I think the story would hopelessly confuse an opera audience were it told the way Faulkner himself told it," notes Menides, whose own poems have been published in numerous magazines and anthologies. "Still, we had to ask ourselves how we could simplify the story and still respect the complexities and insights of the book. And, we wondered how we could preserve Faulkner's lan-

guage and, at the same time, externalize the action, which in the book exists mainly in the minds of the characters."

The solution was to use Faulkner's own words—and only Faulkner's words—to tell the story, changing tenses where necessary and reordering the passages from the book to create a simplified, linear story line. In the finished libretto, page numbers appear beside the lines of dialog, directing the reader to the pages in the Random House edition of the novel from which the words were taken.

"David and I wanted this opera to sound like William Faulkner, and not Laura Menides," notes Menides, who spent most of a sabbatical year in 1986-87 crafting the libretto, a task that yielded two complete file drawers full of drafts.

"What made this Faulkner novel especially adaptable," McKay says, "is that it has a tremendous amount of dialog and expository prose. It's also one of the few Faulkner novels that doesn't fly all over the country."

With the basic ground rules established, Menides and McKay selected the elements of the story they would include in the opera. "David let me know what he needed as a composer," Menides says. "He said he needed some love scenes, so we have scenes where we contrast the young love of Dewey Dell and her boyfriend, Lafe, with the mature love expressed by Addie and Whitfield. He wanted a seduction, so we have the seduction of Dewey Dell by the pharmacy clerk. And, of course, he wanted to stage the flood and the fire."

In addition, after much discussion, McKay and Menides agreed they wanted the tone of the opera to stress the essentially comic vision of the novel. "Walker Kerr said tragedy celebrates the greatness in people that is destroyed, and comedy celebrates the littleness or irrationality that survives," Menides says. "By that definition, this book has comedy and tragedy.

"At the end, Darl goes insane and is put in an institution, and Addie is dead. They are the great characters. But we know by the end that the other characters, along with all of the irrationality that has gone before, will survive. Life is irrational and survivors make the best of it. But there's more than that. Faulkner was very concerned with the word 'endurance' and used it in his Nobel Prize acceptance speech. He had a great deal of respect for survivors."

In the tradition of theatrical grand comedy, perhaps best represented in the high comedies of Shakespeare, such as *As You Like It* and *Much Ado About Nothing*, the opera *As I Lay Dying* ends with a masque. The characters sing and dance to music that incorporates popular tunes of the 1920s, such as "Put Your Little Foot Right Out," "I'm Forever Blowing Bubbles" and "I Love You Truly." Here and there are references to wedding marches by Wagner and Mendelssohn.

"High comedies frequently end with big celebrations of life and the human activities that signify life, like marriage and mating," Menides says. "And, in fact, at the end of *As I Lay Dying* we have Anse, who not only has new teeth, but a new wife. And in Dewey Dell, who is still carrying her baby, we have the prospect of a new life."

As McKay and Menides began to shape the opera, it became apparent that McKay's bitonal score (bitonal music simultaneously uses two musical keys) would be the vehicle for reintroducing much of the complexity and layered meaning that had been sacrificed to simplify the novel's story line. "The fact that several characters can sing at once in an opera," Menides says, "permits you to create a sense of irony. For example, when Anse says he is a luckless man, the other characters simultaneously mock him."

Through the use of leitmotif, a technique in which a composer develops a unique musical theme or style for each central character, McKay was able to convey a sense of the personalities and unique identities of the men and women who populate Faulkner's novel.

"Each character is distinguished by the music," he says. "For example, Addie's music is charged with the passion and wisdom of the heart. Dewey Dell's has a lightness and superstitious quality to it. She doesn't have the reflective powers of Addie—hers is a sort of circus passion, so as a composer you can almost have her sing in nursery rhymes, which you couldn't do for Addie."

David McKay pauses to reflect during a rehearsal of the opera at his home. As a composer, he says he is responsible for nearly all of the details involved in getting his work performed.

When Dewey Dell enters the pharmacy where she will be seduced, McKay establishes the shady character of the pharmacy clerk with what he calls a "sleazy jazz style." The scene ends with Dewey Dell's cry, "That son of a bitch!," which McKay stretches out in a powerful evocation of the anger and resignation Dewey Dell feels as she realizes that the "medicine" the clerk has given her is actually turpentine.

Special instrumental sections help paint some of the larger themes of the opera. In addition to the "Gramophone Masque" at the opera's conclusion, there is a pastoral overture to Act I that evokes the opera's rural setting. "Rushing Water Music," which introduces the flood in Act II, and the "Fire Overture," which introduces the scene where Darl burns down the barn, suggest the power of nature and remind the audience, McKay says, that natural forces can be harbingers of tragedy.

"Faulkner got his flood from the story of Noah in the Bible, and his fire from the Book of Revelation. These are two classic ways of bringing people to a recognition of what happens to you if you lead a sinful life," McKay says, noting that in *As I Lay Dying*, Faulkner seems to express ambivalence about the evangelical Christianity of his native South, reflected most strongly in the character of Cora, a neighbor who speaks fervently of sin and salvation without really understanding what the words mean.

McKay composed *As I Lay Dying* with a computer and a synthesizer. As the notes are played on the synthesizer, they appear on the screen. The setup simplifies the process of polishing a musical work, which McKay says can take much longer than writing the original composition.

In the opera, this ambivalence is captured in the portrayal of Addie's death, which occurs near the end of Act I. While the performers sing a traditional spiritual, Rev. Whitfield (a name, McKay notes, that is shared by an 18th century English preacher and the insane asylum in Jackson, Miss.) blesses the Bundren house. "Whitfield, with whom Addie has had an affair, is supposed to bring her to her knees in prayer," McKay says. "There's a lot of double irony in that scene."

Just as the Bundrens must complete an arduous journey to complete their mission in *As I Lay Dying*, David McKay and Laura Menides realized early on that their odyssey from idea to finished opera would not always be an easy one. That trek began with more than nine months of negotiations, during which the fate of the project rested in the hands of two lawyers, a New York City agent, a host of Faulkner scholars, and Jill Faulkner Summers, William Faulkner's daughter.

"Working through her agent, I sent Jill Faulkner Summers an early version of the libretto, because we felt that before she would give us any rights to the book she would want to know how respectful we were going to be to her father's work," Menides says. "We had to hire a lawyer to work with the agent. He had to do research to find out if Faulkner's daughter had assigned the rights to anyone else."

The archives at the University of Mississippi contained evidence that a ballet may have been developed based on the book. A group in England had been granted the rights to do a film version, requiring that a clause be added to the final contract excluding performances of the opera in England. However, Menides says, the film project has since fallen through, so it may now be possible to renegotiate that clause.

To verify that the libretto had remained true to Faulkner's words and vision, Menides asked Faulkner's official biographer, Joseph Blotner, to review her draft. A number of noted Faulkner scholars also read the libretto and provided their comments, "which were quite praiseworthy," McKay adds. "These were important people in the Faulkner field, including Noel Polk at Mississippi Southern, one of the senior editors of the Faulkner Random House edition."

To ensure that the musical approach to the opera would also be in keeping with the tone of the novel, Jill Faulkner Summers' agent, Peter Shepherd of Harold Ober Associates in New York, interviewed McKay and listened to examples of McKay's previous compositions. "It turned out that Shepherd had an interest in music, so Summers gave him the ultimate authority to approve that side of it," McKay says. "He liked my music and was pushing with us.

"These are the kinds of hurdles you have to get over when you're dealing with a 20th century writer," McKay adds. "What I thought would be a two-sentence agreement turned out to be a 12-page contract. In the end, though, it was all very satisfactorily concluded and Summers was most gracious in signing the contract."

Before the negotiations reached that happy end, though, McKay and Menides racked up more than $6,000 in legal fees. A grant from WPI's Research Development Council, which provides seed money for new areas of scholarship, paid those costs. The project has also received grants from the Center for the Study of Southern Culture, the Mississippi Arts Council and the Vault Art Trust.

In addition, the Massachusetts Arts Lottery (through the Worcester Cultural Commission) provided $3,000 of the $7,000 needed to cover the cost of hiring performers and renting studio space to make a cassette recording of excerpts from the opera. Earlier this year the tape was played on radio station WBAI in New York City while McKay and Menides provided commentary. WPI's Humanities Department also contributed funds to the project, a portion of which came from a grant the department received during the 1970s from the Mellon Foundation.

A friend of mine once said, 'David, don't dare become a composer unless there's nothing else in life you can do,'" McKay says. "Those words are burned on my mind—I've never forgotten them. I'm still not sure that I might just take her advice, because it can be hell on Earth."

In his years as an active composer, McKay has learned that his work is far from over when the last note is committed to the page. "I write the initial version of a piece quickly, and though I spend a lot of time polishing, that's only part of my job. I wrote the first version of *As I Lay Dying* during one summer five years ago, but since then I've been caught up in the hassle of getting funding, of interviewing, hiring and training singers and musicians, of rehearsals, of getting a production organized, and of getting everything and everybody down to Mississippi.

"I've got to leave our family home in Maine early one morning in July and drive to Boston, hoping that singers and instrumentalists from all over New England are going to converge at 11 a.m. at the Northwest Airlines terminal. I've got two people driving down to Mississippi from Pittsfield, Mass., with all the percussion instruments, and I've got to hope they don't break down or get caught for speeding somewhere. This is what my friend was talking about."

Despite his impressive list of musical credentials—more than 50 published works, including operas, concertos, chorales, cantatas, a mass and a requiem, and commissions from groups as diverse as the National Cantors Convention and the American Antiquarian Society—McKay began composing seriously relatively late in life.

A native of Athens, Ga., he grew up in Starkville, Miss., about 75 miles southeast of Faulkner's stomping ground. "Starkville was considered a big place," McKay says, "and yet there wasn't a paved road leaving town. That was typical in Mississippi then."

He was born into a musical home, his mother having studied classical piano at Juilliard, but he says he was never encouraged to think seriously of music as a career. He took piano lessons from his aunt and Starkville neighbor, Annie Laurie McKay, and eventually enrolled at Mississippi State University, located a stone's throw from his Starkville home.

In 1945, after his freshman year, he left Mississippi State when he became, he says, "the last man in Mississippi to be drafted during World War II." After serving for a year as an oboist in the U.S. Air Force Band, he matriculated at Oberlin College in Ohio, where he majored in history and took a wide range of music courses. After earning his bachelor's degree, he traveled on to Providence to study for a master's in English at Brown University, working as an English instructor during his final year there.

In 1956 he was hired by WPI's Humanities Department to teach English. Six years later he earned a master's degree in music from the New England Conservatory. While WPI's undergraduate catalog continued to list him as an associate professor of English until the late 1970s, he had already been teaching composition and music theory for many years by the time he became a professor of music in 1979.

Building on a consuming interest in Americana and American history that he attributes to his roots in the South, McKay became an expert on 17th, 18th and 19th century American music and earned a widespread reputation as a musicologist with his numerous scholarly articles, edited volumes of early American music, performances with his own ensembles, lectures at colleges and universities across the country, and four well-regarded recordings on the Folkways label. *William Billings of Boston*, a biography of the foremost American musician of the 18th century, which McKay co-authored with Richard Crawford, a professor at the University of Michigan, won the Kinkeldey Award as the best book on music published in America in 1976.

More than anything, he once explained, it was a singer at the First Unitarian Church in Worcester, where for a decade he spent his Sundays playing the organ, that transformed his work as a composer from a hobby to a profession. "Isn't that lovely," she said after singing one of his songs in 1977. From that simple remark by a solitary fan has grown an impressive body of work.

Among McKay's major commissions have been *Terezin—Litany of Innocence*. Based on poems written by children interred in a World War II concentration camp near Prague, the cantata was commissioned by the Holy Cross College Choir for a 1982 East Coast tour. *Devil in the Belfry*, a comic opera based on an Edgar Allan Poe story, was commissioned by the National Poe Society and first performed at the Modern Language Association national convention in 1982. The opera *Bathsheba Spooner*, commissioned by the American Antiquarian Society, was based on the lurid tale of the last woman to be executed in Massachusetts.

Organ Concerto in C, commissioned by the Worcester County Mechanics Association, was performed as part of a celebration of the 100th birthday of the Hook organ in Worcester's Mechanics Hall. McKay wrote *The Yellow Wallpaper*, a monologue opera based on the true story of a 19th century New England woman driven insane by her over-protective husband, with Kent Ljungquist, professor of English at WPI. That opera has been performed around the U.S. and as part of the St. Martin-in-the-Fields concert series in England. *Death Camp Songs*, a cantata based on poems and songs from the Holocaust, was commissioned by the American Conference of Cantors.

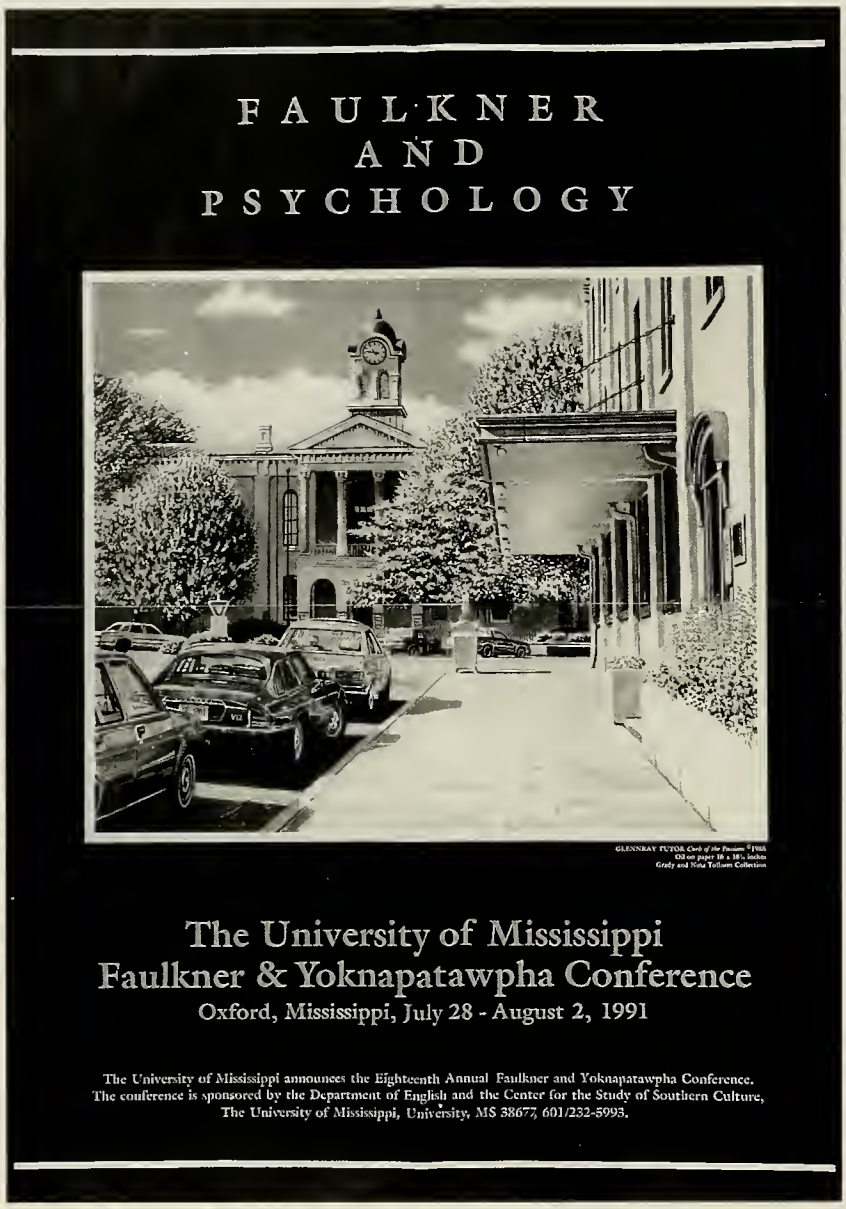
More recently, McKay wrote *A Colonial Requiem*, which used as its text poems from gravestones in a cemetery near his home. He has also completed an anthology of choral settings from Maine and created an exhibit for the American Antiquarian Society on the publication of Mozart's music in early America. This summer, he says, he plans to complete a new book of vocal music.

As I Lay Dying is McKay's first major work to focus on his native South. One of the things that attracted him to Faulkner's book, he says, is the way it captures the essence of Southern life and Southern people. "There's a very vibrant side to this book," he says. "This is a real world, in a certain sense. One of our focuses in writing this opera was to recreate this world—musically and in a literary sense."

As part of their preparation for writing the opera, McKay and Menides spent several days in Lafayette County in Mississippi, the "real world" on which Faulkner based his fictional Yoknapatawpha County.

"Faulkner once said that he wanted to concentrate on his own little postage stamp of the universe," Menides says, "so all of his books after the first two focused closely on this county. Scholars have taken the map of Lafayette and superimposed it on what they think is Faulkner's version of Yoknapatawpha."

With Howard Duvall Jr., an Oxford, Miss., native who now lives in the house where Faulkner resided while writing *As I Lay Dying*, McKay and Menides visited the power plant at the University of Mississippi where Faulkner worked as a stoker each night from 6 p.m. to 6 a.m. Popular legend says that in the early morning hours when the boilers did not need to be stoked very often, Faulkner sat in the coal bunker at a makeshift desk fashioned from a wheelbarrow and composed *As I Lay Dying*.



***As I Lay Dying* will receive its first performance at the 1991 International Faulkner Conference in Oxford, Mississippi.**

Duvall also guided McKay and Menides through the back country beyond Oxford to some of the locations residents believe were the models for the settings in the novel, including the river, the washed-out bridge and the bluff where the Bundren house sat. "When we reached that spot, which is a long drive out into the country," McKay remembers, "Duvall turned to Laura and gestured toward a nearby hillside. 'Ma'am,' he said, 'that's the place.' "

When the lights come up on the stage in the 600-seat concert hall at the University of Mississippi on the opening day of the International Faulkner Conference, it will be the second time conference participants have heard a musical adaptation of the words of one of Mississippi's most famous writers. Among the featured events at the 1985 conference was David McKay's *Premonitions of Yoknapatawpha*, a song cycle based on 10 of William Faulkner's poems.

"The interesting thing about Faulkner's poetry is that it prefigures all of the major themes that come out in his novels," McKay notes. "For this song cycle I chose 10 poems that show his attitude about sexual aggression, about frustration, about unfulfillment...there is the folk theme about someone who dies at the hands of society, but whose mother sees him as a mythic hero. These are all classic Faulkner themes."

Like the song cycle, *As I Lay Dying* will be performed and not staged. "A fully staged performance of an opera costs about $200,000," McKay explains, "and our grant from the Center for the Study of Southern Culture is too small to pay for that. Even so, the singers have really gotten into it and have decided to memorize their parts and do some blocking. So there will be a limited amount of action." The singers, some of whom will perform multiple parts, will wear hats or other bits of clothing to identify their characters.

Still, McKay and Menides say they hope the performance in Oxford will be a prelude to a full-scale production. Toward that end, in addition to about 300 Faulkner scholars who will be in the audience that night, the conference organizers have invited several opera critics and representatives of a number of regional opera companies.

"Getting new operas produced is difficult," says McKay, who notes that a few much-ballyhooed experimental operas have opened to poor reviews in recent years, making opera companies, most of which are more comfortable mounting productions of classic works, skittish about new pieces. "The Faulkner name makes *As I Lay Dying* a better bet than many new operas, but it will take a big commitment to bring this to the stage."

Should the opera eventually be staged, McKay says he will look forward to hearing his score performed by a large orchestra. The small orchestra pit in the University of Mississippi theater, coupled with the cost of hiring musicians, has limited him to the use of a six-piece brass, wind and percussion ensemble for the performance in July. "An orchestra can give you the lushness and power you need, especially in scenes like the seduction of Dewey Dell," says McKay, who wrote the original version of the score for keyboard using a Macintosh computer and a synthesizer.

As the time for the world premier of *As I Lay Dying* approaches, McKay says he feels a mixture of anticipation and trepidation. "There's always the risk that this has been an exercise in insanity," he says. "Plus, whenever you put your work on a stage you become a sitting duck. Someone might be jealous. A critic might be tired when he's reviewing it. One bad word from a critic can mean everything in the way of future performances."

Still, McKay and Menides say that regardless of the reception *As I Lay Dying* receives, the power of the operatic form will likely draw them to similar projects in the future—in fact, Menides, with a $2,500 grant from the Worcester Cultural Commission, is already at work on a libretto based on *Helen in Egypt*, a poem by H.D. (Hilda Doolittle) that retells the story of Helen of Troy from the point of view of Helen. It is a power that McKay sums up with a quote from W.H. Auden, considered one of the best librettists of the 20th century.

"Auden said, 'Opera is the last refuge of the high style. Opera has to do with heights. Exaggeration is part of its essence and the world of opera is one of high relief, magnification and exaltation. What results is the spectrum of increasing expressive intensity that's available to the opera composer.' "

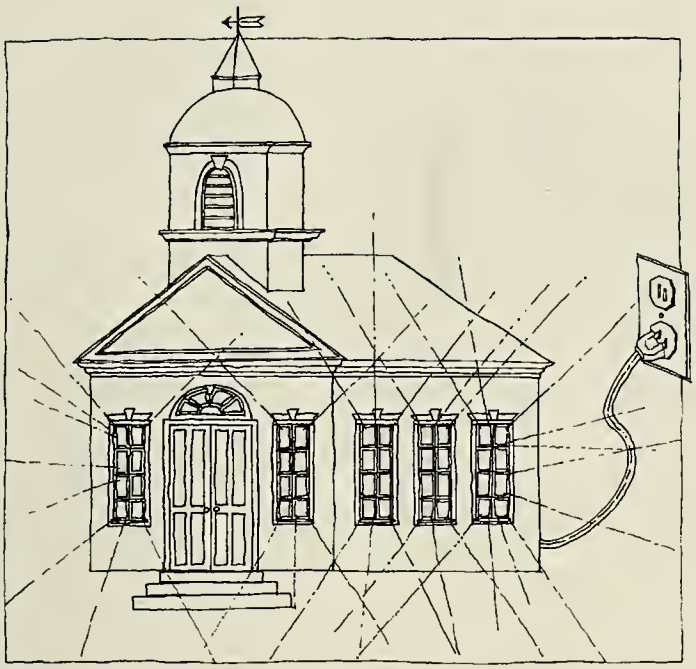


ILLUSTRATION BY SHERRY HOREANOPOULOS

Transforming Our Schools

By Bonnie Gelbwasser

An interview with Frank Newman, president of the Education Commission of the States.

WPI sits at the end of the pipeline in technological education. The young men and women we send into the world each spring arrived at our doorstep after at least 12 years of preparation in primary and secondary schools. We depend upon those schools to do their jobs well so we may continue to enroll and educate tomorrow's scientists, engineers and managers."

With those words, WPI President Jon C. Strauss greeted the graduates and guests at WPI's 123rd Commencement on May 18, 1991. The theme of the ceremony was *An American Agenda: Transforming Primary and Secondary Education in the United States*, which, Strauss noted, grew out of the Institute's recognition of a vital national problem—the need to reform and revitalize our nation's schools.

"In recent years," Strauss said, "it has become apparent that those schools face many challenges that hinder their ability to adequately prepare students for technical careers. Those challenges and their consequences bear directly on the ability of this nation to maintain its competitive edge in our changing world."

One man who is intimately familiar with those challenges is Commencement speaker Frank Newman, president of the Education Commission of the States. Newman, best known as the author of the two Newman reports on higher education completed in the 1970s for the Department of Health, Education and Welfare, told the audience that the declining state of education in the U.S. has become a rallying cry for governors, legislators, business leaders, foundations and, most recently, the president and his cabinet.

"We have never had a time since the founding of this country when so much attention by its top people has been focused on education," he said. "The remarkable aspect of that is that there's agreement among all these actors, as diverse as they are, across parties and across regions, that what is needed is not just a little tinkering—not just the tightening of a few screws here and there—but a fundamental transformation of the education system."

Created in 1985, the Education Commission of the States is an interstate compact that helps state leaders improve the quality of education. It recently joined with the Coalition of Essential Schools in a program called RE:Learning, a major national effort aimed at answering the call for redesigning the total school system. The program is grounded in the belief that this redesign must focus on the primary purpose of schooling: helping all students learn to use their minds well. And, it must involve everyone—from the schoolhouse to the statehouse.

Based at Brown University, the Coalition of Essential Schools is sponsored by the National Association of Secondary School Principals and the National Association of Independent Schools. RE:Learning came out of a five-year study of American high

schools led by Theodore R. Sizer, whose books include *Horace's Compromise* and the forthcoming *Horace's School.* Sizer's books trace the experiences of Horace Smith, a fictionalized composite of teachers Sizer has met. These teachers yearn for more time to devote to their students and more flexibility within the school day. They hope their students are better prepared for life as a result of spending time in their classes. Schools in six states—Arkansas, Delaware, Illinois, New Mexico, Pennsylvania and Rhode Island—are now participating in RE:Learning.

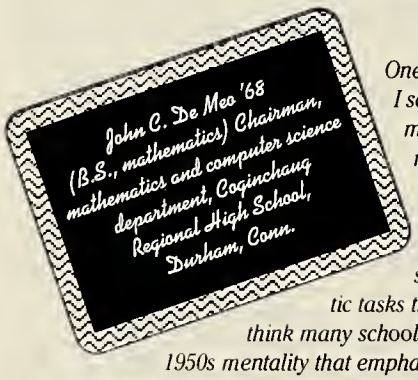
In this interview, Frank Newman talks about some of the things he has learned about school reform over the years. Interspersed with Newman's comments are the thoughts and ideas of a few of the more than 400 WPI alumni who work as primary and secondary school teachers and administrators. Many are graduates of WPI's two long-standing in-service institutes, the Master of Natural Science and Master of Mathematics programs. WPI solicited their input in a recent survey of aumni working as school professionals.

This report also includes, on pages 27 to 29, a look at some of the things WPI is doing to meet its obligation to help revitalize precollege education and keep the pipeline flowing.

QUESTION: How do we build successful schools and school systems?

ANSWER: We need a different way of thinking about schools, because the current system has gradually developed into a fairly sizable bureaucracy. Over the last 15 years or so, there has been a trend in that bureaucracy toward more rule making, and for the rule making to move up—that is, for the states to make more and more of the rules, and for the schools and school districts to make less and less. By rules I mean what lesson plans should look like, what textbooks should be used, how many hours should be spent on this and how many on that, and so on.

For example, 47 states have passed laws that require teachers to be tested before they can be certified. Nearly every state has added more extensive testing requirements for students. States have begun to mandate the number of courses required for graduation from high school.



One of the greatest challenges I see in this country is determining and agreeing upon national and local standards of excellence against which we can measure our students' performance. These standards need to be realistic tasks that are worth mastering. I think many schools are still operating with a 1950s mentality that emphasizes pencil and paper calculations and one-step problem solving. We need to start from scratch and examine what is important for students to learn to be successful in the 21st century.

Q: And the people in the trenches in the individual states have had little choice but to follow these mandates?

A: That's right. And they weren't, for the most part, consulted on them. Did this work? In part, but only in part, although it did create more interest in and concern about education. Test scores did go up, but not thinking skills or graduation rates. As people looked at how schools were operating, they began to realize that teachers were becoming more like factory workers. This was happening at a time when we were discovering that we ought to give factory workers more autonomy and flexibility.

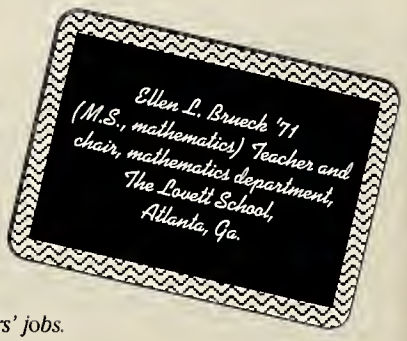
Now we know that we have to do the same thing for teachers. If we really want kids to learn how to think, we are going to have to say to teachers, "Let us help you learn how to teach kids to think. Then *you* decide how you're going to do this."

Research over a period of decades has made it clear that there must be a radical revision in the way we teach children. The teacher-directed, competitive classroom is clearly ineffective for the majority of students. Effective hands-on, cooperative, participatory strategies are well-known. Moving to enlightened strategies has proven to be difficult. Implementation will require a commitment from all areas of society. There is no short-cut, top-down road. Americans as a people have to learn to truly believe in the promise and ability to learn in all of our children. We have to build a grass-roots movement that believes in children, is willing to take risks, and is open to letting go of discredited attitudes and behaviors.

Q: A school in Vermont lost some of its administrators and couldn't attract replacements. So the teachers got together and formed a coalition to make school-related decisions. Despite the lack of administrators, interest in learning and excitement increased. Does that say terrible things about administrators, or does it say good things about teachers?

A: We've had similar experiences. When we started RE:Learning, everybody was down on teachers, believing that schools were bad because teachers were bad. Thomas Kean, the governor of New Jersey, suggested that before we talk about reform, we find out if teachers want reform. So we started "Talks with Teachers." Tom and I and some New Jersey legislators went around the state meeting with groups of teachers. We later did the same thing across the country. It wasn't a surprise to find that teachers were quite interested in reform.

What surprised and appalled us was the answer to our question, "How much time do you spend during the day talking with the principal or with other teachers about how to improve teaching and learning in your schools?" We found that more than half the teachers never spent any time talking with each other or with their principal. Part of the problem is that most principals see themselves as administrators, and not as educational leaders.



The educational system is top-heavy with administrators. Put personnel in the classrooms. Put money in the classrooms. Pay administrators less than classroom teachers and the good teachers will stay in the classrooms and not opt for a "promotion" into administrators' jobs.

Q: Are teachers adequately prepared to be agents of change in the classroom?

A: It has begun to dawn on everybody that to improve schools you have to create a set of circumstances in which the energy and creativity of the teacher and principal become unleashed. Why is it that only 1 to 2 percent of our schools are doing this? The answer is that teachers don't know how because that isn't how they were trained. They were trained by teachers who stood in front of the room and lectured. They sat passively and repeated what the teacher said. So they teach the same way. To some degree, these teachers are less equipped than ever to do the task we now recognize needs doing.

Teachers generally teach the way they've been taught. The cycle must be broken in order that a learning theory based on students' activities and experiences be implemented. Teacher education programs must be restructured to allow for learning that is experience-oriented, based on students' own beliefs and ideas, where small-group, cooperative work is commonplace, and scientific study begins with forming questions, collecting data and checking out ideas.

Q: Where does reform start? Is it expensive? And who will pay for it?

A: It's not expensive. Teachers need a small amount of money to be able to talk to each other, but we don't need to change the cost structure of schools. Our goal is to do all these things within the existing cost structure. We're saying, decide what really matters in terms of how kids learn, focus on that, and that shouldn't cost us any more. In fact, it may cost us less in the long run.

Reform begins with talking. In any organization people need to talk together regularly. The leader, in this case the principal, needs to talk to the teachers all the time—all year long. How can you run a successful organization if you don't do this? We're talking about taking risks, about trying new ideas. All of this cries out for a different environment, climate and tradition—a new organizational approach inside the school and, therefore, in the school district and in the state. You have to start at both ends. The state must change policies so that when a school tries to reform itself it gets rewarded rather than beat up. And the school must change itself, because that's where the action's got to be.

On the Educational Front Lines With WPI's School-College Collaboration

When it was created in 1988, WPI's School-College Collaboration in Mathematics and Science Education *(WPI Journal,* Winter 1989) had some ambitious goals. First and foremost, it was to work closely with local schools to help them create relevant curricula in math and science. In the process, the college hoped to play a role in restructuring precollege education in the United States.

To help accomplish these goals, the collaboration has employed the skills and energy of its undergraduates, who have completed their required projects at area elementary and secondary schools, and its faculty, who have run programs in the schools and given numerous presentations demonstrating that technical and scientific careers can be exciting and rewarding.

And, finally, the collaboration has worked to find funding for these and other programs aimed at getting the WPI community involved in precollege education (grants have already been received from the Greater Worcester Community Foundation and the New England Educational Association for Loans).

"Our approach has been eclectic," says Francis J. Trainor, a longtime Worcester elementary school principal who now directs the collaboration as an affiliate assistant professor in WPI's Interdisciplinary Studies Division. "We have attempted to explore as many strategies and initiatives as possible as we've built partnerships with local school teachers and administrators and with the business community."

One measure of the success of the program is the increase in proposals from local schools for projects to be performed by WPI students. In the collaboration's first year, 10 student teams completed Interactive Qualifying Projects in the Worcester public schools. Some 70 requests from public and private schools have been logged for the upcoming academic year.

The student teams that have responded to such requests have developed courses in engineering, basic electricity and computer programming, among other topics, and have gone into the classroom themselves to teach such subjects as chemistry, biotechnology, trigonometry and environmental and space science.

Last year students helped teachers establish an outdoor science classroom and nature sanctuary at Mill Swan Magnet Elementary School in Worcester, which serves differently abled students. Bertrand LaChance '91 developed a way to teach seventh-graders at Worcester's Burncoat Senior High School about statistics and probability by having them study toxic waste in nearby Lake Quinsigamond. Student teams working with Mohamed Noori and Joseph Rencis, associate professors of mechanical engineering, developed a computer-aided design curriculum for a school in West Boylston.

Another goal of the collaboration is involving women and minorities, who have been traditionally underrepresented in science and engineering. In 1989 the Institute received a $10,000 grant from the Xerox Foundation for a minority enrichment program called COMET (Combining Mathematics, Enrichment, Technology and Science), which sends WPI professors and students into the schools to present experiments, conduct small-group discussions, and lead parent-student workshops.

In 1990 the Xerox Foundation gave WPI a $150,000 grant to help found a new student project center in Puerto Rico, the first WPI center specifically aimed at helping bring minority students into the mainstream of

(Continued on Page 28)

Q: The best reward for successful programs would be to let them continue and expand, but in a recessionary economy, that doesn't always happen.

A: Sure. The plain fact is we're short of money everywhere. But the mistake is to think money will solve the problems. Let me give you an example. Last year New York City spent about $6,100 per pupil. The national average was $4,800 or $4,900, so New York ought to be in great shape. It's not in great shape. Why? Because most of what New York City spends its money on are things that don't really add to education.

It's not enough to have money, you have to have money that matches purpose. That's why you want more control at the school. If a program is working wonderfully and the school has control over its resources, the people there can say, "Well, okay, we want this program to continue. It means we're going to have to take some administrators out and put people back into the classroom and so on, but that's more important to us than letting this program go down the tubes."

The greatest threat to precollege education is a lack of commitment to excellence in public education. This commitment means a willingness to spend the dollars necessary, to establish standards we want students to achieve, and to hire, develop and retain teachers who are effective with children and dismiss those who are not.

Q: If money is not the answer, how do you make schools more successful?

A: Kids basically like learning, but we make learning boring and unrelated to the real world. So kids find it irrelevant. They'd like to avoid school, but they hang in there as best they can until they can drop out.

The solution is to make education exciting; to connect it to the real world. For example, there's a growing interest in teaching math—at all levels—in ways that connect the teaching to real problems. That's terribly important. I remember watching a bunch of kids who were in a project where they worked in teams to solve problems.

Periodically the teacher would stop the class and say, "Wait a minute, kids. We're all having trouble multiplying fractions. Let's talk about how you do that." He had these kids on the edge of their seats. They wanted to know how to do this, because they were trying to solve a problem. And, of course, they learned five times as well and they remembered it eight times as long.

(Continued from Page 27)
engineering and science education. The insights WPI gains through maintaining a center in Puerto Rico should prove instrumental as it seeks to encourage underrepresented minority students to consider engineering and science as attainable careers.

Recently, United Technologies Corp. provided an initial grant of $125,000 for *Diversity at WPI*, an enrichment program for minority youth. Students in the elementary grades who have an interest in and aptitude for science and mathematics will be recruited by the Connecticut Pre-Engineering Program. In the summer before their senior year of high school they will spend four weeks at WPI taking part in Frontiers in Science, Mathematics and Engineering, a two-week enrichment program, and getting hands-on experience in a campus or industrial research lab. Students who successfully complete the summer program and their senior year of high school will be admitted to WPI with their full financial need met.

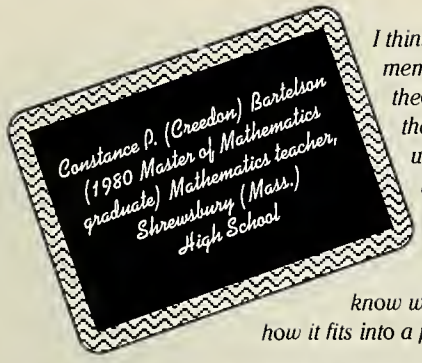
Neil Collins, principal of Quinsigamond Elementary School in Worcester, has participated in the collaboration from the beginning, when an IQP team taught geometry to fifth- and sixth-graders at his school. After that experience Collins obtained a grant that funded a project in which students used the Logo computer language and Lego toys to help children learn about computers and robotics.

Scott M. Sheehan '93, one of the developers of WPI: The Science Connection, works with students at the Oakham (Mass.) Center School.

"With their math and science backgrounds, the WPI students have provided technical expertise to our teachers and brought the excitement of these disciplines to our classrooms," Collins says. "They've also changed a few misconceptions—our students have seen that not all scientists are isolated in laboratories where they never talk to anyone, and that women can be scientists and engineers, too."

"The collaboration is our most popular area for student and faculty projects and programs," says Lance Schachterle, associate dean of undergraduate studies and head of the Interdisciplinary Studies Division. "Each year nearly 100 of our 500 to 600 IQP students elect to complete their projects in the classroom."

Among the other collaboration initiatives is the Visiting Scholars Program in Mathematics/Public School in Residence, which provides junior and senior high school teachers the opportunity to teach in a college setting for a full academic year. The visiting scholars organize the annual WPI Invitational Mathematics Meet, in which students from New England high schools compete for scholarships and team awards. Two years ago WPI, the Massachusetts Biotechnology Research Institute and the New England Science Center developed a series of workshops on biotechnology for fifth- and sixth-grade science teachers. The workshops, taught by WPI faculty, were directed by Joseph Bagshaw, professor and head of



I think a lot of students learn, memorize and swallow facts, theorems and definitions, but they can't think about how to use or apply them. They learn the information only to get to the next step. They can repeat every rule they have ever seen—but they don't know when they should use it—or how it fits into a problem.

Q: How can schools get down to the business of teaching kids to think and solve problems when so many seem to be troubled by discipline problems?

A: Discipline problems begin to fall away when kids get interested in school. Part of the reason schools have discipline problems is that students don't want to be in school because they feel put down and it's boring. When you get kids really involved, daily attendance rates go up and truancy and other problems go down. We also want much greater parental involvement. In every school where successful reform has come about, getting parents involved turned out to be important. A self-confident school invites parents in; a bureaucratic school is afraid to do so.

Q: How can a parent become involved if he or she is the sole supporter of a family, or part of a family that is not making enough to provide adequate housing or adequate clothing? Do we have a long way to go before we can truly get parental involvement?

A: No, and it's terribly important to understand that. I'll always remember talking to a marvelous principal during a meeting with some governors. She had turned around a terrible school and made it a really first-class school. One of the things this principal had done was get the parents involved.

One of the governors said to her, "Where did you find the parents?" She said, "Wherever they were. If they were in the bars, I went to the bars. If they were in the projects, I went to the projects." And you could just see this woman going into the bars and saying, "You know, we need you to come to the school." But they came. It took her a year or two, but they became involved. Parents need to feel that somebody in the school values them. Everything I'm talking about has been done in the worst of settings, where kids come to school hungry, where kids come from struggling, unsafe backgrounds. When you turn a school around it becomes the place kids want to be, because it's exciting and it's safe. The kids value the school. In a sense, the school in such a setting has an easy task of gaining the

the Biology and Biotechnology Department.

Because of the value they attach to the goals of the collaboration, individual departments and department heads have pursued their own initiatives in precollege education. For example, James P. Dittami, associate professor of chemistry, last year worked with WPI students and the principal and a teacher at the Oakham (Mass.) Center School to launch "WPI: The Science Connection."

Through the program, a museum, a resource center and a science laboratory/classroom have been created at the school, and an in-service training program has been established for teachers in grades K through 6. Dittami has applied for funding from the Massachusetts Board of Regents to expand the Science Connection to all the schools in the five-town Quabbin Regional School District.

Other professors who have participated in the collaboration include:

- Samuel Rankin, head of the Mathematics Department, who conducted an after-school math workshop program at May Street School in Worcester;
- mathematics professors Ansuman Bagchi and Balgobin Nandram, who are exchanging ideas with teachers and conducting workshops at the same school under a grant from the Worcester-based Hiatt Foundation;
- James W. Pavlik, head of the Chemistry Department, who conducted a special program at WPI on infrared spectroscopy for students in Shrewsbury High School's advanced placement chemistry course. In collaboration with the New England Association of Chemistry Teachers, the Chemistry Department also organizes regular conferences on chemistry education for high school and college chemistry teachers;
- and chemistry professor Ladislav Berka, who familiarized teachers and students at Cambridge Rindge and Latin School with college-level chemistry. In February Berka was among six Massachusetts college professors to receive $100 seed grants from the New England Association of Schools and Colleges to support a school/college alliance.

"What makes our programs so successful is that so many students and faculty from diverse backgrounds—but all with a passion for math and science—can serve as teachers, advisors and role models in the public school classroom," says Schachterle. "Our project teams must submit a well-researched report to their faculty advisors and the classroom teachers, so, in addition to learning something about themselves and about their future professions, they leave something permanently useful behind."

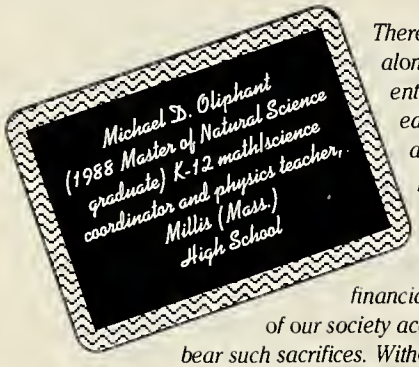
"People in the Worcester Public Schools are thrilled with WPI's School-College Collaboration," says Gale Nigrosh, development specialist for Higher Education/Business Partnerships. "What makes it work so well is that it's institutionalized—projects are required of students, and the faculty and advisors are a vital part of each project. We don't have a similar program anywhere in the city."

Nigrosh notes that Frank Trainor has been working with Worcester parents, faculty and students on plans for Worcester's City View Discovery School, a new magnet school that will open in September. "He helped us develop the math, science and technology curriculum for the new school, which has been designed to encourage children to use decision-making, problem-solving and communications skills to learn and to develop the confidence to explore new educational areas," she says.

In presenting the school to Worcester parents, Nigrosh has noted that WPI faculty and students will be involved with the school on a continuing basis to implement a hands-on math and science program that extends beyond the classroom, utilizes the school grounds, and is integrated with all subject areas. More than 1,440 students applied for 260 openings at the school.

—Bonnie Gelbwasser

kids' attention because everything else is bad. What happens to kids when you don't give them that kind of excitement and support? Somebody else does—a gang or somebody—because it's a vacuum that will be filled.



There is too much lip service alone paid to education. Parents must support the goal of education for their children as a top priority. They must pay for this education (as they do for all other community services they expect). This requires financial sacrifices by all members of our society according to their ability to bear such sacrifices. Without such sacrifices, the gains we made in the 1960s are in real danger. For example, some schools are already cutting back on science education, eliminating an extra period for labs and reducing teachers' contact time with students.

Q: What are the steps to get education back on track? Where do we begin?

A: Americans want a silver bullet, but there's no single thing we can do. People are interested in public school choice, alternative forms of certification, a longer school year—anything that sounds like it'll solve the problem. And the answer is, it's a fundamental series of things we have to do. It's a lot like the restructuring of industry, which is tough, difficult and time-consuming. You can't do any one thing, you have to do lots of things. And it's not just education we're talking about. Education just happens to be the most prominent. We've got to do it for the health care system, for the legal system, for industry. This is a long, hard battle.

Second, where do we begin? We've already started at multiple levels. States are key factors. They've got to change how they make policy, and they're in the process of doing this. Schools are key factors. They've got to change how they run themselves, and some of them are beginning to do that. Teacher education programs are key factors. They have to change their approach to teaching, and a few are beginning to do so.

The obvious starting point is setting expectations, setting goals—what do we expect of students? Increasingly, states are saying, "We want all students to be able to think." You know, we never said that before. They are saying, "We want kids to be creative." We never said that before, either.

Students must be allowed to be in charge of their own education, even if that leads to some failures in high school. We must not direct their every move as so many well-meaning educators try to do.

Inside Our Schools: A Troubling Picture

Unmotivated students. A lack of parental support. Inadequate resources. These and other issues ran through the comments from alumni who responded to WPI's recent survey of elementary and secondary school teachers and administrators. Their answers paint a troubling portrait of the state of our schools today. Here is a sample of their thoughts:

We need to develop a resolve in our young people to want to excel and to be willing to work for it. I think the problem lies in the lack of fortitude and vision in our country, not in the educational enterprise.

— **Roy K. Baer** (1968 Master of Natural Science graduate) Chairman, science department, Wachusett Regional School District, Holden, Mass.

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The greatest challenge? The dropout rate. We must attempt to make teaching more meaningful by trying new things. In this attempt teachers should be like nomads—never quite getting there, but always trying.

— **Paul C. Potvin** (1972 Master of Natural Science graduate) Physics, chemistry and astronomy teacher, Otter Valley Union High School, Brandon, Vt.

In our lower-middle-class schools, the "pursuit of excellence" has no meaning. The city is not willing to fund, the parent not willing to pay, and the student doesn't seem to care to learn beyond what is entertaining. I am being either pessimistic or realistic—take your choice.

— **John H. Holmes '68** (B.S. chemistry) High school science teacher, Lynn (Mass.) Public Schools

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Students are not particularly interested in intellectual challenges. Since the early 1980s the major motivation has been money—a lot of it—and discovering the easiest way to be a millionaire by age 30.

— **Margaret K. O'Brien** (1988 Master of Natural Science graduate) Chemistry teacher, Duxbury (Mass.) High School

Today's students are pupils only. They feel entitled to an education, thus losing sight of the fact that they have to work to achieve that education. They see the teacher as someone who pours knowledge into their heads, and not someone who guides them through the learning process. The few students who learn the process are ridiculed and ostracized by many of their peers.

— **Elizabeth A. Belevick** (1974 Master of Natural Science graduate) Science teacher, North High School, Worcester

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Inspiring youngsters to pursue academic achievement is a great challenge. Currently the student work ethic is nonexistent. If it isn't instant and fun, most students aren't interested. You can imagine what that implies about physics, calculus and computer programming.

— **Louis F. Lowell** (1978 Master of Natural Science graduate; 1990 Master of Mathematics graduate) Physics, calculus and computer programming teacher, Georgetown (Mass.) High School

Q: Can we assume we'll have some sort of national consensus on what constitutes successfully teaching a kid to think?

A: Yes, we're moving in that direction. At a recent summit with governors at the University of Virginia, six goals were identified. Now the governors, the White House staff and the Congress have a panel, headed by Governor Roy Roemer of Colorado, that will decide how we measure against these goals.

This process raises awkward questions. For example, one of the goals is for the U.S. to be first in the world in math and science. Well, you have to define what you mean by *first*. And, you have to ask how we will know if we're first. That's a hard problem. Another goal is for every child to be ready to learn. That's easy to say, but hard to do. But at least we're trying. We start by setting our expectations and our goals. Then we measure against them, and if we're failing, we're failing. Let's say so. And then let's get to work on trying to correct that failure.

Q: What's your time line?

A: I think we're talking about a 10-year effort.

Q: Some of the teachers WPI recently surveyed seem pessimistic and demoralized. Many seem overwhelmed. To them, 10 years may seem like a long time.

A: Part of the reason people are demoralized is that this is a tough task, but it's also because we haven't had a good battle plan. Our battle plan in the '80s was, "We will need more money." And we got it. We got 30 percent more money across the country in real dollars after inflation. That's a huge increase in money. The question is, did it do any good?

Now things are going the other way. In other words, we put people in the position where the only answer seemed to be getting more money. Now, when we have less money, does morale have to go down? Look at Xerox, which had to cut the size of its organization and rebuild its quality. Did morale go down? No, it went way up, because people had a battle plan and they knew what they were doing. They knew that the success of the enterprise was at stake. And they knew that somebody cared about them.

In part, teachers are demoralized because they feel they are at the end of a long chain and no one cares about them. So we must turn things around and say to the teacher, "You're everything. Let's help you learn how to teach people to think. Let's create a climate that allows you to decide how to run the daily classroom activities." When you say this to teachers, their first reaction is, "I don't know how to do this," but you get to the point where people get excited. And if you say, "Along the way you're going to have to make some hard budget decisions," they say, "Well, okay, let's get on with it."

There is no one single challenge facing us—there are many, and they are all interrelated, including the dissolution of the traditional family unit, students' short-term need for gratification, tenure systems that reward seniority and not merit, negative stereotyping of scientists and mathematicians in the media, ineffective leadership by state and national leaders (including our "education president"), and the failure of society to instill proper values in youth.

Mark M. Skinner '85
(B.S., mechanical engineering)
Physics and general science
teacher, St. Sebastian's
Country Day School,
Needham, Mass.

About Frank Newman

Frank Newman has written extensively on education policy. In addition to the Newman reports, *Report on Higher Education* and *National Policy and Higher Education*, he is the author of *Higher Education and the American Resurgence* and *Choosing Quality: Reducing Conflict Between the State and the University*, reports completed for the Carnegie Foundation for the Advancement of Teaching in the 1980s.

Newman earned bachelor's degrees in electrical engineering and naval science and economics from Brown University, a master's in business administration from Columbia University, and a Ph.D. in history from Stanford University. For seven years he was Stanford's director of university relations; in 1974 he was named president of the University of Rhode Island. In his nine years in that post he managed to strengthen academic programs and triple funding for research despite shrinking budgets.

He left Rhode Island to serve briefly as a presidential fellow with the Carnegie Foundation. In 1985 he was named president of the Education Commission of the States, which conducts policy research, surveys and special studies, serves as a clearinghouse, organizes state, regional and national forums, and fosters national leadership and cooperation in education. Among its most important priorities are embracing diversity, transforming teaching and promoting system change.

Q: The Newman reports came out in the 1970s. Two decades have come and gone and we don't seem to be any further along. What went wrong?

A: Four or five months ago I was at a dinner celebrating the start of a big national effort on mentoring at-risk kids. The closing speaker was a marvelous fellow named Reggie Williams, who had played linebacker for the Cincinnati Bengals. Reggie said, "When I was with the Bengals, we were one of the great defensive teams of all time. We really were hot. Our problem was we could never play good, tough defense until we got down to about our own 10-yard line. I used to say to myself, 'We'd be a lot better team if we'd start somewhere around the 40,' but we always waited until we got backed up to our own end zone. That's the way America is." And everybody sat there nodding their heads and saying, "That's right. That is the way America is." And that's what has happened. We knew we had problems in education, but we had a lot of things on our minds. Now we've finally realized, "Hey, wait a minute, this is make or break."

Though She's Left Wall Street Behind, Maureen Higgins is Still Making Dough

Three years ago Maureen Higgins was making "dough" as a Wall Street bond analyst. Today she makes another kind of dough, as a bread baker and tea party caterer based in Niantic, Conn. Though she may have left behind the high-stakes world of the New York City money game, Higgins, who received her B.S. in management engineering from WPI in 1981, is still making an impression on the Big Apple.

The New York Times recently called her elegant chicken salad sandwiches (made with almonds and basil butter) "delicacies," and *The New Yorker* noted that the cognac-drenched fruitcake she prepares for Manhattan Fruitier is praised by fruitcake lovers and non-fruitcake lovers alike. Patrons of the Espresso Bar at the Paramount Hotel appreciate her unique touch with breads and confections, the magazine added.

Higgins has had a long love affair with creative cookery. During her student days at WPI she taught an Intersession course in vegetarian cookery and spiced up her interest in foreign cooking as an exchange student at The City University of London. As editor-in-chief of *Newspeak*, the student newspaper, she wrote occasional articles about food. Over the years she has worked as a restaurant reviewer, a private cook and a part-time employee in a school cafeteria.

In the fall of 1981 she settled in Manhattan, where she found a job as a counterperson at E.A.T., a gourmet food store on the Upper East Side. Later she was hired as a cheese counterperson at another gourmet specialty shop, Dean & DeLuca, in SoHo. Within a month she was promoted to cheese department manager and buyer and was lecturing on cooking with goat cheese as a member of the New York Women's Culinary Alliance.

In 1983, while still with Dean & DeLuca, Higgins enrolled full time at New York University Graduate School of Business to earn an M.B.A. A guest lecturer for one of her courses would later become her boss when she was hired by the Bond Portfolio Analysis Group at Salomon Brothers. In 1987 Higgins married Christopher Wall, a painter, and purchased her late grandmother's cottage on Smith Cove in Niantic.

"The purchase coincided with my increasing estrangement from the corporate world," she says. "I began to consider career changes that would involve working with food and spending more time in Connecticut."

Her plans gained momentum after she catered a benefit for a dance company. She planned the menu, did the shopping, and cooked and served food for 125 people—all by herself. "I can still hardly believe I did it," she says. At the dance company's next benefit she catered to 200 guests—again, by herself. The event was so successful she gave her notice to Salomon Brothers and started her own Manhattan catering service.

"I decided to call it The Mad Hatter," she says, "because my friends at work told me I was 'mad' to drop a well-paying job as a financial analyst to begin an uncertain career as a tea party consultant in cocktail-partying Manhattan." The name, she says, is also a reflection of her longtime interest in collecting and wearing extravagant hats.

Despite the cautions from her Wall Street colleagues, Higgins discovered that many New Yorkers were getting away from cocktail parties and enjoying tea parties instead. "Tea drinking is making a comeback," she says, "partly because of a growing health consciousness and partly because of its social nature. It gives men and women the opportunity to meet during the happy hour without suffering the ill effects of alcohol."

Higgins offers a light and lively menu, highlighted by thin slices of homemade bread and unique sandwich fillings. Fish mousse served with dill butter is a favorite request. A light afternoon tea might include cucumber, watercress and ham sandwiches, classic shortbread, lemon curd tartlets, anise seed pound cake, fresh strawberries and, of course, freshly brewed teas.

For a full tea the menu might include chicken-almond sandwiches, smoked salmon pinwheels, orange-currant cream scones with clotted cream and homemade preserves, cheese straws, English cheese tarts and lemon-lime tea bread.

Higgins adds personal touches to her parties. She uses flowers, vegetables and herbs from her Niantic garden and often supplies tablecloths and tea services. Typically, she shows up in one of her head-turning chapeaux.

She says she can make arrangements for up to 200 guests, and often caters engagement and wedding parties. Once, as a birthday gift, a mother requested that she serve tea to a party of one—her daughter. She has also, as a Valentine gesture, served tea at a customer's bedside.

In addition to the usually sophisticated offerings in her bread line (Pane di Como, a basket-risen French bread, or Pane all 'Uva, raisin-packed gnarled loaves, are examples) Higgins will turn to basics in order to please her clientele. "If there are to be children at my tea parties, I'll gladly serve peanut butter and jelly sandwiches with punch," she says. "But I don't do Kool-Aid!"

—Ruth Trask

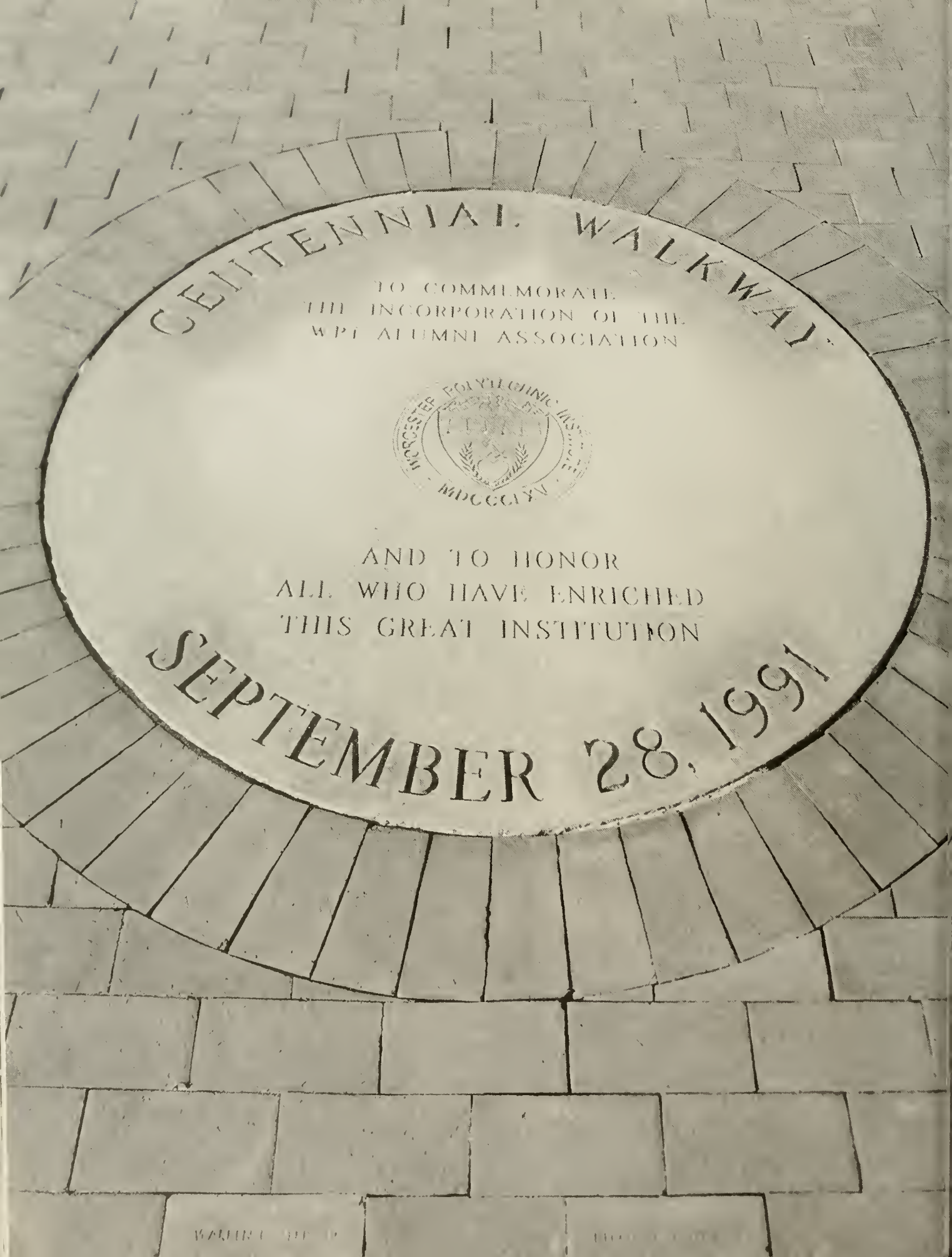
Maureen Higgins, right, abandoned the high-stakes world of bond analysis for the lure of high-class catering. Her tea parties, like the one above, are feasts complete with homemade sandwiches, tarts, fruit and other goodies. She is known for her imaginative baking—one such treat is the bunch of three-pepper cheese straws in the fruit and cheese basket below. Higgins likes to adorn her tables with flowers from her Connecticut garden (opposite page).

WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

SUMMER 1991

Three for the Future: WPI's New Presidential Young Investigators


CENTENNIAL WALKWAY
TO COMMEMORATE
THE INCORPORATION OF THE
WPI ALUMNI ASSOCIATION
AND TO HONOR
ALL WHO HAVE ENRICHED
THIS GREAT INSTITUTION
SEPTEMBER 28, 1991

WPI Journal

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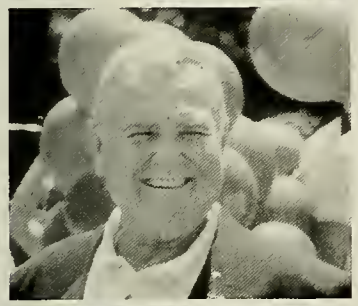

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This year the WPI Alumni Association celebrates the 100th anniversary of its incorporation. The organization has changed a bit in the past century, but its mission is still the same: to bring the Institute and its graduates together.

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Front Cover: WPI's new Presidential Young Investigators: clockwise from lower left, Tahar El-Korchi, assistant professor of civil engineering, holding a concrete sample containing embedded optical fibers; Kenneth J. Balkus Jr. '82, professor of chemistry at the University of Texas at Dallas, with a model of a zeolite crystal; and Peter L. Levin, assistant professor of electrical engineering, with one of his computer simulation programs. Story on page 4. Photo by Janet Woodcock. **Opposite:** The centerpiece of the new Centennial Walkway, which commemorates the 100th anniversary of the WPI Alumni Association. Story on page 26. Photo by Michael Dorsey. **Back Cover:** The tower of the Washburn Shops is surrounded by the lush greenery of the WPI campus. Photo essay on page 16. Photo by Donald F. Berth '57.

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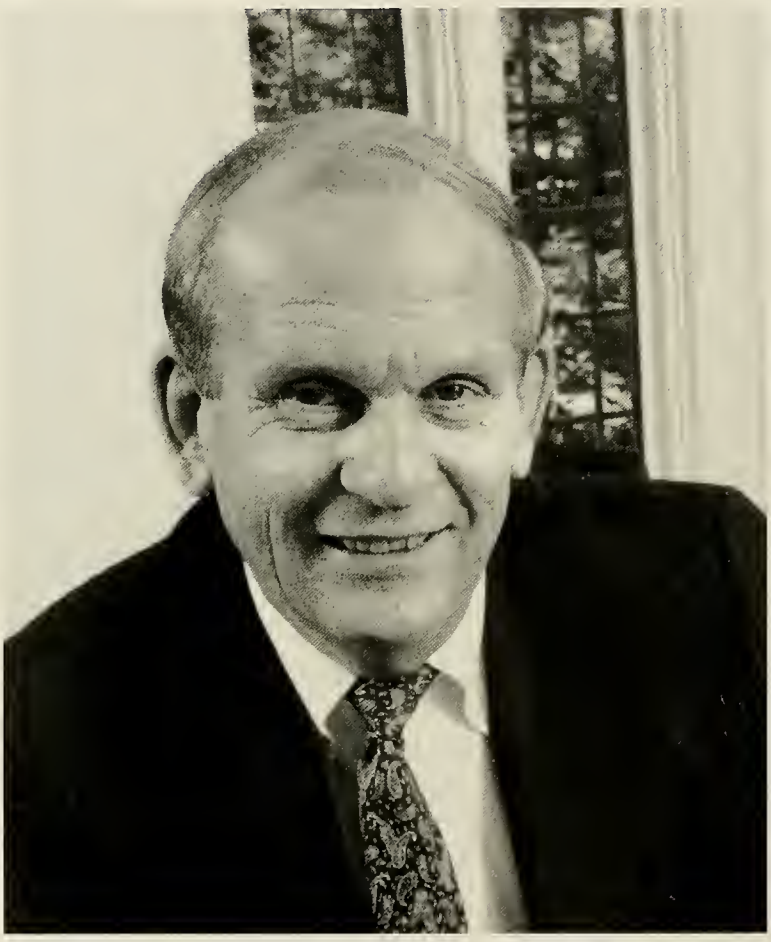
A Circle of Pride, Involvement and Support:

Reflections on the Alumni Association's 100th Anniversary

In the early 1870s, when the WPI Alumni Association was just getting off the ground (it would be officially incorporated in 1891), its founders envisioned an organization that would bring together the college's graduates for their own benefit, as well as that of their alma mater. Over the years that guiding philosophy has been maintained and enhanced.

Today, nearly 120 years later, the fundamental mission of the Alumni Association, a purpose defined so eloquently in the organization's charter, remains unchanged: "Increase the usefulness, elevate the standards, and exalt the honor of Worcester Polytechnic Institute in its service to our country and to mankind by developing strong bonds of loyalty between WPI alumni and their college for reciprocal benefit and for active, friendly comradeship among WPI alumni."



JANET WOODCOCK

Stephen J. Hebert '66, secretary of the Alumni Association since 1971.

In 1969 a series of discussions began that would result in a major change, not in the role of the association, but in the way in which it conducts its business. The talks led to the transformation of the association from an independent, self-supporting organization of alumni into an operating division of the Institute.

That was more than 20 years ago, shortly after I joined the association as assistant alumni secretary-treasurer, but I can vividly recall the breadth and depth of those discussions and the clarity of vision behind that decision. By becoming part of the college, the association has developed a closer and more clearly defined relationship with the institution it supports. The move has proven to be in the best interest of all alumni.

More important, the organizational changes ultimately adopted in 1971 were important steps in the expansion and development of the WPI Alumni Association and its programs. Seen in retrospect, the joining of the college and the association was a prototype for the mergers and acquisitions that would characterize corporate America during the succeeding two decades. The vision that Bob Higgs '40, Jim Donahue '44, WPI President George Hazzard, and Vice President for University Relations Tom Denney had for enhancing WPI through that merger has proven to be extremely well-focused and appropriate.

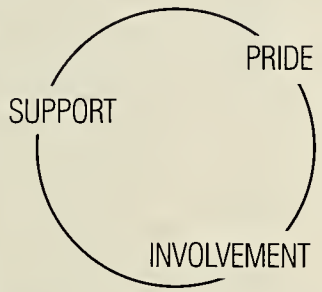
Bob Higgs was president of the Alumni Association when the concept of the merger was being developed. I recall sitting with Bob in the Ambassador Club at the Greater Pittsburgh airport in 1971, shortly after I became alumni secretary. We were talking about how to maximize alumni involvement and voluntary support for the college. After much reflection, Bob drew a circle on the back of a napkin and around it wrote "pride, involvement, support."

That diagram has been used hundreds of times since then to illustrate the real goal of the association. It doesn't matter where you start on the circle or whether you travel clockwise or counterclockwise, the message is valid: pride begets involvement, involvement begets support, support begets involvement, involvement begets pride, and so on. These three factors are the backbone of any alumni association.

The WPI Alumni Association has been

blessed by the superb leadership of its many presidents. In the post-merger era we have been served by Bob Higgs, Jim Donahue, Walt Bank '46, Fran Harvey '37, Bill Julian '49, Jack McCabe '68, Pete Horstmann '55, Harry Tenney '56, Paul Bayliss '60, Dick Kennedy '65, George Abdow '53 and, currently, Joel Greene '69. I'm confident that we will continue to benefit from equally strong leadership in the years ahead, and that this association of WPI graduates will continue to play an extremely important role in the success of the Institute.

One of the most important aspects of the Alumni Association is volunteer involvement. One summer day as we sat beside the water at his home on Lake Willoughby, Vt., Bill Julian, who presided over the association from 1977 to 1979, realized that the involvement of WPI alumni in the life of their alma mater could be significantly enhanced and expanded. From that realization came the Master Plan Committee chaired by Dick Davis '53, which, perhaps more than any other single group in the past 50 years, spurred the association to new levels of activity.



The programs that resulted from the Alumni Association's Master Plan included the Corporate Contacts Program, aimed at expanding interactions between the college and the corporations around the country that employ its graduates; the Class Agent Program for the Alumni Fund, considered one of the best of its type in the country; an expanded Alumni Council, the governing body of the association, which has increased the involvement of individual classes in the association and enhanced their contributions to the college; and the unique corporate Matching Gifts Program, perhaps the most successful effort of its kind in America.

In 1980, the peak year for alumni involvement at WPI, more than 1,400 graduates—almost 15 percent of the living alumni at the time—were participating in the activities of their college in one way or another. While that percentage has declined as the number of graduates has increased, the level of volunteer involvement in WPI continues to be extraordinary.

The Master Plan has been updated several times since 1978 and it will continue to be improved in the future. It's important to remember, though, that rather than changing the mission, the vision or the focus of the association, the various iterations of the Master Plan have consistently reaffirmed the organization's fundamental purpose and philosophy, while expanding its horizons and expectations.

When he was president of WPI, the late George Hazzard frequently told gatherings of alumni that one of the most important things they could do for their college was to be conspicuous by their success. Over the past 126 years WPI has had its share of extraordinarily successful graduates. They have included Robert Goddard '08, the father of modern rocketry, Arthur Smith '33, former chairman of United Technologies Corp., and Herman Hollerith '17, inventor of the IBM punch card.

That pattern of success and pride has continued unabated. Today, for example, three alumni head *Fortune* top 60 companies: Bob Stempel '55, chairman and CEO of General Motors, Paul Allaire '60, chairman and CEO of Xerox, and Romeo Ventres '48, chairman and CEO of Borden Inc. In fact, only Yale University, among all the colleges and universities in the nation, can say that more of its undergraduate alumni are chairmen of *Fortune* top 60 companies.

That is an extraordinary accomplishment for a small engineering college, one that should make all of us extremely proud. But it's not just Bob, Paul and Ro, it's all WPI alumni—in all walks of life—who instill feelings of pride, respect and admiration in their fellow graduates and in their alma mater. We all do so much to promote the college and enhance its image on a daily basis. Indeed, the 19,000-plus living WPI alumni are the college's best salespeople and its most constant proponents.

MARVIN RICHMOND

Robert E. Higgs '40 in 1969.

Today the WPI Alumni Association has a staff of three full-time professionals and five support people. Their goal is to provide support for the many alumni programs and to the various committees that are charged with the responsibility for creating and implementing those many and varied programs.

The focal point of the college's alumni activities is the Alumni Association's home on campus, the stately Higgins House. I invite all alumni to visit Higgins House and the alumni offices whenever they are on campus, and also to stop by the President's Office on the first floor of Boynton Hall to share their thoughts, ideas and perspectives.

Together we will make WPI a stronger and more vibrant institution in the days and years ahead, and further enhance the reputation of the college. Yes, Bob Higgs, your circle of pride, involvement and support remains the cornerstone of the association. It has been the launching pad for excitement, support and success for your alma mater. I urge every graduate to be as involved and supportive as possible and, in the process, to share the pride that is so well deserved.

—Stephen J. Hebert '66

Hebert is secretary of the WPI corporation and secretary/treasurer of the WPI Alumni Association.

The Cream of the Crop

By Michael Dorsey

WPI's three new Presidential Young Investigators are already making their marks with leading-edge research in fields that run the gamut from asphalt to zeolites.

In April 1991 Worcester Polytechnic Institute hit the equivalent of an academic home run. On that day three researchers—two members of the faculty and one alumnus—were named Presidential Young Investigators, one of the most prestigious honors a young scientist or engineer can receive. Awarded by the National Science Foundation and funded by the Office of the President, the PYI award is presented each year to about 200 of the nation's most talented young scholars.

While recipients must have demonstrated accomplishments in scholarship and teaching, the true purpose of the PYI award is to single out and encourage a select group of young academics who are at the beginning of promising careers in teaching and research—careers that have the potential to advance the state of the art in science and engineering and, in the process, enhance the nation's competitiveness.

This year's awards bring to three the number of WPI faculty members who have earned the status of Presidential Young Investigator. James E. Rollings, associate professor of chemical engineering, received the award in 1985 (see page 8).

WPI's three new winners represent two engineering disciplines and one science: Tahar El-Korchi is an assistant professor of civil engineering, Peter L. Levin is an assistant professor of electrical engineering, and Kenneth J. Balkus Jr. is an assistant professor of chemistry at the University of Texas at Dallas (UTD). Their research covers a broad spectrum of topics, from the simulation of complex electromagnetic phenomena, to the study of construction materials, to innovative uses of crystalline compounds called zeolites.

The PYI award will give the recipients the freedom and the resources to continue this research by providing each $25,000 per year for five years. The NSF will also match up to $37,500 each year in industry support, for a total of up to $100,000 per year or up to $500,000 for the term of the award. Unlike many government research awards, there are few restrictions on the use of the PYI funds. With his award Levin has already hired assistants to rev up the pace of his research; Balkus says he plans to use part of his first-year allocation to pay his way to an international zeolite conference in Czechoslovakia, a trip he would otherwise have been unable to afford.

Perhaps equally important, by joining an elite group of young scholars, Presidential Young Investigators gain the kind of recognition, credibility and visibility that opens doors. Balkus says the award can be a particular boon to faculty at smaller colleges and universities like WPI and UTD (a branch of the University of Texas that specializes in mathematics, science and engineering).

"I've been interested in getting more involved in the American Chemical Society," Balkus says. "A few weeks after getting the award I was invited to sit on a long-range planning committee and now I'm running for alternate counselor for my section. Perhaps there's no connection, but no one was calling me before this."

All three recipients say they were surprised when word of the awards arrived. "There are a small number of universities that receive the bulk of these awards," Balkus says. "Unless you teach at one of these, you automatically think you're a long shot."

"It was such an honor to even be nominated," says Levin, "and to realize that others think you are qualified for this award. That's certainly as far as I expected it to go, so when I got that phone call I was completely shocked."

After the euphoria died down, each winner said he began to feel the weight of responsibility that accompanies the award. Says El-Korchi, "You settle down and ask yourself, 'What does this all mean?' It's a great opportunity to pursue research interests that I've planned to address for so long. Now I have to do some deep thinking and plan a strategy so that in five or six years I'll be at the cutting edge in some area of work. I'm grateful for the opportunity, but I also know that the expectations for me are high."

In the following pages you will meet WPI's new Presidential Young Investigators.

Teaching an Old Crystal New Tricks

Kenneth Balkus '82, assistant professor of chemistry at the University of Texas at Dallas, attributes a good deal of the success he has realized in his young career to his WPI education. In particular, he says the opportunity to do leading-edge research in inorganic chemistry with professor Nicholas K. Kildahl—work that resulted in a published paper when he was still a junior—gave him an excellent head start on graduate school.

Surprisingly, one thing he says he did not acquire at WPI, a college known internationally for its research on crystalline compounds called zeolites, is his own interest in these compounds. "I was a chemistry major and was unaware of some of the state-of-the-art chemistry that was going on under the same roof in the Chemical Engineering Department, particularly by the late Leonard Sand. I'd like to say there was some influence there, but there wasn't."

In the three years he has been on the faculty at the University of Texas, Balkus, who earned his Ph.D. in inorganic chemistry at the University of Florida and spent two years as a postdoctoral fellow at the University of Pennsylvania, has earned a growing reputation—and an impressive record of corporate, government and foundation sponsorship—for the novel applications he has found for zeolites.

"Historically, zeolites have been studied for their ability to act as catalysts, with applications in petroleum refining and things of that sort," Balkus says. "But if you're going to make a mark in an area, you can't compete with 20 Ph.D.s at Mobil or Exxon. You've got to find the new applications.

"My success in this field may have something to do with the fact that I was not trained in zeolites," he adds. "I came to this area from a different perspective than most other researchers. That may be one of the reasons I've been fairly successful in getting research funding. It may also be one of the reasons I got the PYI award."

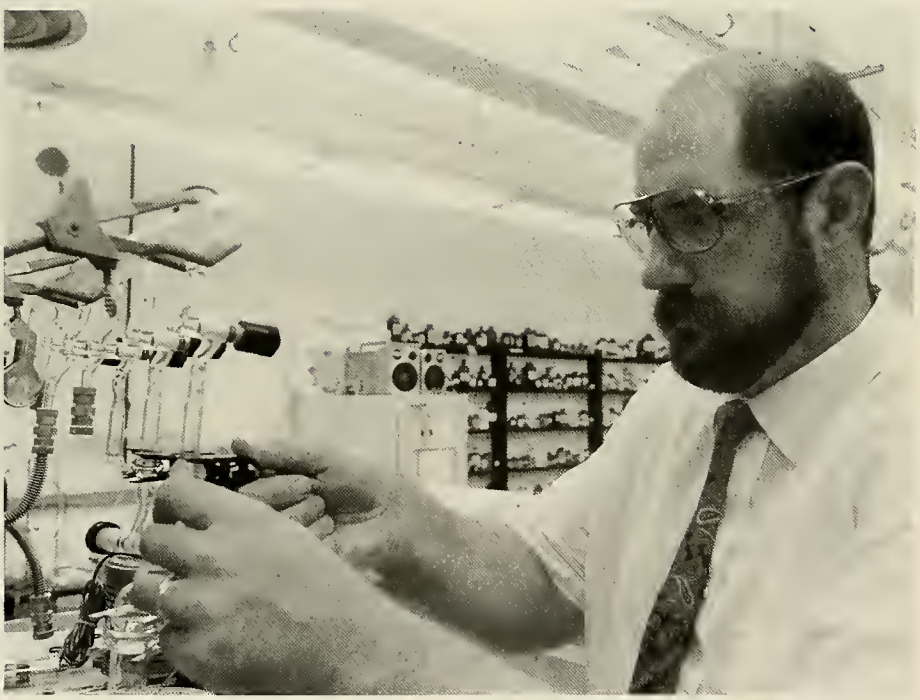
Zeolites are crystals made exclusively of aluminum, silicon and oxygen. What makes them so valuable in a number of commercial chemical processes is their tendency to align themselves into predictable geometric patterns that include highly uniform pores and channels. These precise patterns of holes and passages make them ideal for use as sieves at the molecular level. When modified with other compounds, they can become catalysts, substances that can accelerate the rate of a chemical reaction without being changed by the reaction, or ion exchangers, compounds that can substitute one kind of ion for another when placed in solution. For example, in water softeners, zeolites can replace calcium ions with sodium ions.

Balkus' foray into the realm of zeolites was almost accidental. His initial interest as a researcher was in highly reactive metal complexes. Studying such compounds can be difficult because of their tendency to quickly react with other compounds and change form when they are placed in solution. Balkus hit upon the idea of encapsulating the complexes inside the pores and channels of zeolite crystals, thereby isolating them from the compounds with which they might react.

"We were not the first to do this," Balkus says. "Because of their ion exchange properties, people have long placed ionic complexes inside zeolites to create specific types of catalysts. But we were simply interested in trapping the complexes in the zeolites—like ships in bottles."

To get the metal complexes into the zeolites, Balkus experimented with techniques that had already been reported by other researchers, but he says "trying to get the complex inside the zeolites was just too difficult, and the resulting complexes were too difficult to characterize. In addition, the conditions necessary to accomplish this were severe and the range of complexes you could work with was limited. So we said, 'Why don't we just build a zeolite around the complex?'"

They found that they could, in fact, get zeolites to condense around the metal complexes. More important, they discovered



F.W. BIDDENSTADT

Kenneth Balkus in his laboratory at the University of Texas at Dallas.

that metal complexes can act as templates, guiding the crystallization process and fostering the formation of unique zeolite lattices. Balkus says templates have been used before in zeolite synthesis, but organic compounds, rather than inorganic molecules, are almost always chosen as templates because organic molecules can be easily removed, leaving just the zeolite behind.

The use of metal complexes as templates was a novel idea, and Balkus says he has applied for a patent for the technique. He has also received a grant from the National Science Foundation and support from the Petroleum Research Fund and the Robert A. Welch Foundation to continue the work.

Once Balkus and his team had found an effective way to encapsulate metal complexes in zeolites, they began to look for new and interesting applications for these materials. They found, for example, that the encapsulation process can make some complexes that normally exhibit no catalytic properties act as catalysts. In some cases the metal complex and the shape of the zeolite's passageways work in tandem, with the zeolite controlling which compounds get in to react with the complex and determining which products get back out into the solution to be recovered.

One application for encapsulated metal complexes that Balkus is currently exploring in his lab may have a significant impact on the field of medical imaging. In collaboration with Dean Sherry, a fellow professor of chemistry at the University of Texas, Balkus is using zeolite/metal complex combinations as contrast agents for magnetic resonance imaging (MRI). A contrast agent causes a specific region of the body to show up as a bright area on an MRI image.

While researchers have developed MRI contrast agents for a number of organs or tissue types, to date no one has been able to create an agent that works satisfactorily in the harsh environment of the gastrointestinal tract. Clinical trials are now under way on agents made from iron oxides, but, Balkus notes, these compounds have an unpleasant taste and can cause side effects. In addition, these magnetic materials appear to cause artifacts in the MRI images, which are produced with a combination of radio waves and a strong magnetic field.

Balkus decided to encapsulate potential GI-tract contrast agents in zeolites, which are resistant to the acids and other destructive chemicals in the digestive tract. It was theorized that the zeolite "cage" would shield the metal complexes from the digestive juices, while still enabling them to react with water, which is essential to their activity.

F.W. BIDDENSTADT

Balkus and graduate student Mark Newton work with highly reactive metal complexes, which Balkus is able to encapsulate in zeolite crystals.

"MRI contrast agents work by altering the magnetic properties of water," Balkus says. "We found that if we immobilized the metal complex in the largest pores and channels of the zeolite—the places water was most likely to reach—we got better results."

It was also hoped, he says, that encapsulating the contrast agents would protect the body from their potentially toxic effects. Over the past few months the zeolite contrast agents have undergone numerous tests in the laboratory of Dr. Stuart Young, a professor of radiology at Stanford University. Using test animals, Young found that the agents produce outstanding images and appear to cause no harmful side effects.

Using MRI to create images of the GI tract—something rarely attempted now—will offer significant advantages over the traditional GI series, which employs X-rays. For one, MRI scanners can create three-dimensional images of the body, something traditional X-ray machines can't do. "With X-rays you can't easily resolve the various twists in the intestines and bowels the way you can with MRI. This means you may miss important signs of disease."

One unusual property of zeolite-based contrast agents will be appreciated by the patients who may eventually ingest them. "If you've ever had a traditional GI series, you know it can be pretty awful," Balkus says. "You have to drink a concentrated barium sulfate solution, which is as thick as a milk shake and tastes like chalk. Unlike barium, zeolites are most effective in very low concentrations. This should be much more pleasant for the person who has to drink them."

Balkus, Young and Sherry have applied for a patent for the zeolite-based contrast agents and have started a company, Texas Magnetics Inc., to spearhead the development, testing and eventual marketing of these materials—a process that could take up to five years. The university has supported the creation of a business plan for the new company, and Balkus says the next step is obtaining venture funding for the firm.

In collaboration with Bruce Gnade, a senior scientist in Texas Instruments' central research laboratory in Dallas, Balkus is pursuing another nontraditional application for zeolites—chemical sensors. While a number of other ventures in this relatively new area of zeolite research are aimed at producing devices that will sense the presence of chemicals by detecting weight or optical changes, Balkus and Gnade are attempting to marry zeolites with silicon chips to produce simple electronic sensors that can detect combustion products, like carbon dioxide,

carbon monoxide and nitrous oxides.

"With chemical sensors, the key issues are selectivity, sensitivity, stability and reversibility," Balkus says. "Zeolites have advantages in most of these areas. In fact, we feel we can make a high-quality combustion gas sensor that is less expensive than a lot of the electronic devices on the market."

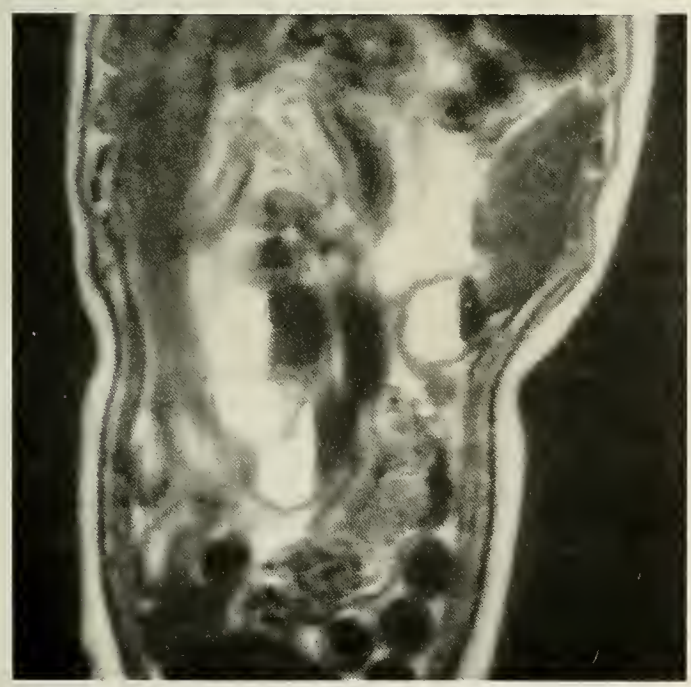
To make these sensors, Balkus says, they will place a metal coating on a silicon wafer, crystallize a layer of zeolites on top of that, and then place another conductive layer on top of the zeolites to form a simple capacitor. When current is applied to the two conductive layers, a voltage difference will be created across the insulating zeolite layer. When a molecule of a combustion gas is absorbed by the zeolite layer, it will cause a detectable change in the voltage difference.

To make chemical sensors, zeolites can be combined with traditional electronic devices. But zeolites themselves have the potential to become the basis for a new class of solid-state devices, Balkus says. When heated to about 900 degrees Fahrenheit, the open framework of certain types of zeolites will collapse into a dense ceramic phase. Certain of these ceramic materials, such as cordierite, a blue mineral, and anorthite, a type of feldspar, are attractive candidates for use in electronic devices, but have proven too difficult to make with other techniques.

"In our lab we're placing metal complexes inside zeolites and then collapsing them to see if we can prepare a composite ceramic phase with dielectric properties," Balkus says. "These materials could prove useful in a number of electronic applications, including chemical sensors. We've been able to make these materials, but we don't yet know very much about their microstructure or electronic properties."

Another class of materials in which zeolites are playing a novel role in Balkus' lab is polymer membranes, a field Balkus says has exploded over the past decade or so. Membranes made from polymer chains have been employed in a number of industries, Balkus says, but his primary interest is in gas separation. For example, he says, using a polymer membrane to separate oxygen from nitrogen might prove more efficient and less expensive than the traditional method of cooling the gas mixture to the respective temperatures at which the gases liquefy.

"One fairly new twist we're exploring is the use of conducting polymers—polymers with an electrical potential," he says. "We are looking at how the permeability of the membranes to various gases changes as we oxidize or reduce the polymers. It's very difficult to predict how permeable a membrane will be based solely on its structure. We're hoping that by controlling the oxidation or reduction states of the polymer, we can also control its permeability to some extent. Still, we know there will be limits to how much we can do."



In this MRI image of a dog's gastrointestinal tract, the lighter areas have been enhanced with the zeolite-based contrast agents developed in Balkus' lab.

To get around those limits, Balkus says he is working with a graduate student and John Ferraris, a polymer chemist on the faculty at the University of Texas, to add zeolites to polymer membranes. By merging the permeability of polymers with the selectivity of zeolites, Balkus says he hopes to create highly selective gas membranes for a number of industrial applications.

To date, most of Balkus' research has focused on zeolites, but he has also experimented with a closely related class of materials known as molecular sieves. While zeolites are made exclusively from aluminum, silicon and oxygen, molecular sieves—which also have a uniform network of pores and channels—can have other elemental compositions.

Researchers have found that synthesizing molecular sieves in the presence of fluorine can enhance their selectivity and reactivity. Balkus is using this technique in hopes of finding some new and potentially valuable catalysts. He recently published an article on a catalyst that can be used in a process in which methyl butyraldehyde is converted to isoprene, a precursor to natural rubber.

"People have tried to use zeolites as catalysts in this process," Balkus says, "but have always gotten a mixture of different aromatic products. Some of the fluorinated sieves we've made seem to be more selective."

Balkus says the success he has realized in his comparatively brief career may come as a surprise to at least a few of his former professors in WPI's Chemistry Department. While he did well in his courses and project work (he graduated with distinction), and even served as president of the chemistry club, known as the Skeptical Chemists, he says he did not fit the mold of the typical chemistry student.

"I'm not sure how many people in the department really took me seriously," he says. "I was a lineman on the football team until I was injured in my junior year. I was active in my fraternity, I played rugby, and I worked a lot of off-campus jobs. I even ran for student body president—and lost. Chemistry was simply not my life."

Today, however, Balkus says he must work to find time in his life for anything beyond his work in the laboratory and the classroom. Whenever possible, he water skis with his wife and daughter on a lake by their home in The Colony, Texas, and the former college athlete keeps in shape by training a few days each week in tae kwon do, a Korean martial art in which he holds a black belt.

But mostly, he says, his days are consumed with work. "In my exit talk with my Ph.D. advisor, he said, 'You've got to work at least 10 years solid—maybe seven days a week and holidays—but in the end it will be worth it, because in your later years that work will start to pay off.' This is the time in which I have to build my reputation."

Cultivating Invisible Fields

It's a debate that's been around almost as long as there have been colleges and universities: Is the primary role of a college professor imparting knowledge to a new generation, or furthering the basic understanding of the world around him? In other words, is a faculty member's place in the classroom or in the laboratory?

During his brief time as an assistant professor of electrical engineering at WPI, Peter Levin has given little thought to the education vs. research debate, for the line between his own teaching and scholarship is fuzzy, at best. "In my lab we don't even try to tell them apart," he says. "Until the very end of a project, when it's time to start putting words around the things we've been doing and publish a paper, we make no attempt to distinguish between education and research."

Levin's lab is the Computational Fields Laboratory (CFL), a large room on the third floor of Atwater Kent Laboratories crammed full of computers and sophisticated engineering workstations. Founded by Levin in the summer of 1989—just a year after he joined the WPI faculty—it has been supported by more than $200,000 in grants and equipment donations from such companies as Apollo Computer, AT&T, Digital Equipment Corp. and Rockwell International.

Under Levin's direction, the lab has become a hotbed for the development of software in numerical analysis, a field in which highly sophisticated mathematics is brought to bear to solve engineering problems far beyond the reach of pencil-and-paper calculations. Backed by the might of modern computers, engineers are using numerical analysis to tackle problems that seemed unsolvable just a few decades ago.

The goal of much of modern numerical analysis is the simulation of complicated physical phenomena, such as the movement of fluids, the behavior of materials in a manufacturing process, or the performance of modern jet aircraft at hypersonic speeds.

Techniques like the finite element method and boundary element analysis break a system into discrete parts, solve the often arcane equations that represent the forces at work in each segment, then reassemble the segments to produce a highly detailed model of the system. Using these methods, engineers can learn more about fundamental physical processes and test designs for new products without having to build costly prototypes.

In the CFL, numerical methods are being applied to a variety of phenomena in electrical engineering. The focus is on generating solutions to challenging problems in electromagnetics. Since all of modern electrical engineering can be defined—to some extent—by electromagnetic interactions, Levin's work has far-reaching implications.

Over the last half decade Levin has devoted most of his energy to the development of software packages that simulate complex electromagnetic phenomena. His programs pack sufficient computational power and sophistication to make them sought after by researchers in university and industrial labs around the world. But their raw power is matched only by the elegance of their user interfaces and graphics capabilities, qualities that enable even undergraduates to easily enter problems and appreciate their solutions. In fact, the programs have become integral parts of WPI's course sequence in electrostatics and have been adopted by more than 20 other colleges and universities.

Making A Difference

Six years ago, when he became WPI's first Presidential Young Investigator, James E. Rollings, professor of chemical engineering, was already well-known for the new analytical techniques he was developing for the study of the structure, properties and function of large biological molecules like starch—work that has found important applications in the food processing and medical products fields, among others.

Rollings says he used the early years of his PYI award to continue that research and to work as a liaison between the biotechnology community and manufacturers of laboratory instruments. "There were many instrument makers who knew how to develop good research tools, knew why those tools were useful, but didn't know how to reach the end user in the lab."

He convinced manufacturers to contribute their machines to his lab, and then through his own research with graduate students, short courses and other means, helped promote their use in biotechnology research laboratories

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Peter Levin on the steps of Atwater Kent Labs.

"One of the things that distinguishes our codes from similar programs is that they are extremely easy to use," Levin says. "This is because they are not meant to be just research tools, but are educational programs, as well. Because they're written for students, they have to be as intuitive as possible, and I think we've been remarkably successful in that regard."

Levin's interest in educational software began when he was an undergraduate at Carnegie-Mellon University. He discovered that he had a natural talent for computer programming, a skill that opened a new door of understanding to him. "For me, programming became a catalyst for learning new things," Levin says. "I never felt I truly understood a phenomenon until I could program a computer to model it.

"To make a model of something, you have to take it apart and understand its elements. Doing that in an abstract sense requires talent, to some extent, but to a much larger degree it requires persistence and interest. You have to *want* to know."

As a graduate student at Carnegie-Mellon, Levin applied his knack for programming to the physics of electromagnetic fields, the subject of his graduate research. The result was the Charge Simulation Program, a software package he developed as part of his master's thesis. The program enables a user to enter an actual problem in electromagnetics and then see the resulting electromagnetic field in graphic form on a computer screen.

"Electromagnetic fields are invisible," Levin notes. "It's been the wish of educators and students for years to actually look at field structures—to see their geometries. The Charge Simulation Program enables a user to do just that. There's a real intuitive kind of understanding that comes about once you have that picture in front of you.

Rollings, seated, with Alessandro Corona III, who received his master's degree in 1990.

around the country. In the process he helped advance the state of the art in this emerging field.

Rollings says he gained more than new instruments from these collaborations. He built strong ties to a number of corporations, many of which have brought research projects and sponsorship to his lab. But when Rollings talks about the highlights of these past six years, his attention quickly shifts from the world of his lab to the greater world beyond the WPI campus.

Rolling's interest in biotechnology began in the early 1970s when he was a Peace Corps volunteer in East Africa, where he realized that part of the solution to world hunger lay in helping Third World nations more efficiently grow, process and distribute their own food. While his research continues to take direct aim at real-world applications like these, he says he has learned in recent years that scientists can have an equally important impact on the world around them by becoming active in discussions of international policy issues.

Last year Rollings organized a symposium on biotechnology and public policy for the 200th meeting of the American Chemical Society. As a result of that achievement, he was asked to develop a similar symposium for the 9th International Conference on Biotechnology, which will be held in August 1992 in Washington, D.C., and he has been invited to work on the steering committee for a conference in Czechoslovakia sponsored by the International Scientific Committee for Biotechnology, an arm of the International Council of Scientific Unions.

In his work on international policy, Rollings has made good use of the skills he is gaining as a Kellogg Fellow. He was one of 46 Americans chosen in 1989 to receive this honor by the W. K. Kellogg Foundation. The program's goal is developing capable leaders by helping fellows pursue individual programs of personal growth and education. In recent months, Rollings, whose plan focuses on helping developing nations, has taken a conflict resolution class in Santa Fe and Spanish courses in Guatemala.

While Rollings' goal is to help educate policy makers and scientists in the U.S. and abroad, he says he is also hoping to make a difference here at WPI. Having played an active role in WPI's growing network of global project centers and programs (including a stint last fall as resident advisor in the Washington, D.C., center), he was recently named director of Latin American programs.

His first task in that new role will be helping create a project and exchange program with ESPOL, a technical university in Guayaquil, Ecuador. Projects there will focus on environmentally sound development.

Rollings says he is pleased with the progress he has made since receiving the PYI. "My experience in the Peace Corps taught me to scale my ambitions to something realistic," he says. "Yes, there's a world out there, but you're not going to conquer it. However," he adds, "you can make a difference."

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Levin, center, discusses new additions to one of the CFL's software packages with John H. Petrangelo '93, right. James M. Kokernak '92 works in the background.

"Our programs are not mechanized flash cards," he adds. "Instead, they're more like electronic workbenches. There are no rote answers; in fact, there are no set questions. Instead, there are analysis routines that let students ask 'what if?' questions, and then see the kinds of physical phenomena that result."

Supported by an American Electronics Association Fellowship, Levin completed his Ph.D at Carnegie-Mellon in 1988. His dissertation solved a long-standing problem in particle precipitation, an electromagnetic process used to remove fly ash from the exhaust of coal-fired power plants. Before joining WPI in 1988, Levin served as a Deutscher Akademischer Austaushdienst Visiting Scientist at the Technical University of Munich, where he worked with Hans Steinbigler, a noted developer of simulation software. (Levin will return to Steinbigler's lab this fall to conduct additional research.)

At WPI he began expanding and enhancing the capabilities of the software he developed at Carnegie-Mellon. Today he directs a dedicated research team that includes Ph.D. candidates (the lab will graduate its first Ph.D. student in December), master's candidates, graduate students hired to solve specific problems, undergraduate teams completing Major Qualifying Projects (about 10 MQPs are completed in the lab each year), juniors and sophomores writing utility programs and user manuals, and freshman work-study students. With their help, Levin has taken his original Charge Simulation Program and rebuilt it from the ground up.

The goal is the development of a family of simulation programs, interfaces and graphics drivers (programs that tell a computer how to turn the results of a simulation into two- or three-dimensional graphics) that can be easily interlinked, and that can be adapted to run on just about any kind of computer. The team has completed the development of three major finite element packages. Levin says that prior to receiving the PYI award, he had anticipated completing this process by 1993. The award, he says, has enabled him to greatly accelerate his pace.

"With the PYI grant I've hired assistants, especially computer programmers and theoreticians, who have moved the development program along," he says. "There are still some unanswered questions and unfulfilled potentials, but most of those will be taken care of during this academic year. There will always be some hooks left in the programs for the next person to build on, but in a real sense, a major phase in my career has ended and a new one is just beginning."

The result of this intensive work is educational software that Levin says is "head and shoulders above anything on the market or any publicly available code. Some of the things we give away to other schools are as good as or better than programs for which people pay $10,000."

While ease of use is one major advantage of the WPI packages, Levin says the software also benefits from the inclusion of innovative approaches to solving problems and from algorithms that do things faster and more efficiently than most other programs. For example, a boundary element package, developed by Levin and graduate student Drazen Beatovic with a $68,500 grant from the Westinghouse Educational Foundation, includes a major improvement in this widely used technique. Another package that breaks new ground, he says, is a mesh generator developed by Andrew J. Hansen '91.

"One of the main elements you need to put together a numerical analysis package is a mesh generator," Levin says. "A mesh generator takes an arbitrarily shaped, two-dimensional space and breaks it into a network of triangles, which are known as simplicies. The task of the mesh generator is to produce the best set of simplicies possible."

The grid of simplicies is the pattern of elements upon which boundary element analysis and finite element analysis work. But the ability to break space into a pattern of distinct elements can also come in handy in a number of other applications, Levin says, which makes mesh generators useful in fields as diverse as robot vision and anthropology.

The mesh generator work was supported, in part, by ongoing research grants from Walker Magnetics Group Inc., a Worcester-based company specializing in electromagnetic and permanent magnets and magnetic devices. Using the mesh generator and other software developed in the CFL, Walker's engineers test their designs for new magnets, seeing on the computer screen the shape and density of the magnetic fields they generate and gaining insight into how well the magnets will work. In time, Levin says, the computer will replace the time-tested but wasteful process of building, testing, rebuilding, and retesting prototypes.

Levin used Hansen's mesh generator in a study of the navigational aid Loran C. The project, conducted with Per K. Enge, associate professor of electrical engineering and an internationally noted expert on satellite navigation, involved the use of the Global Positioning System, a network of satellites that send out signals that can be used to pinpoint one's position anywhere on the

globe, to calibrate Loran C, an older navigational system widely used by airplane and boat pilots. For this study, the mesh generator divided a map of the New England coast into an appropriate network of simplicies.

A paper based on the research, one of 14 that have resulted from work in the CFL, was recognized as an outstanding contribution to the Institute of Navigation's Satellite Division Conference in 1990 (the conference had 1,100 participants). "Interestingly," Levin says, "I still know relatively little about how Loran C works; I just know the mathematical description. And Per knows relatively little about finite elements, nor does he need to. That's a mode I really enjoy being in. I like to work with people who are truly experts in their field and let them ask me questions and see if maybe, through the different kinds of experience I've had in mathematics and simulation, I can be of help to them."

In part, the PYI award is supporting the continuing work of Hansen, now a master's candidate in the CFL. As part of his thesis he is characterizing the phenomena of electrical discharge in fluids and gases, a project that builds directly upon the CFL's three finite element programs.

Levin says this software could also help waste management companies design devices to remove aluminum cans from the waste stream, help electric companies develop more efficient high-voltage DC transmission equipment, and help manufacturers improve the capabilities of electric-discharge machining, a technique used to make precision ceramic components for the space and automotive industries.

Another collaboration between Levin and Enge gave the researchers an idea for a novel way to use the computer to teach elementary school students about geography, social studies and science. Under a grant to Enge from the International Maritime Satellite Organization, Levin developed ViewSat, a simulation that will help engineers determine the optimum locations for a worldwide network of ground stations for the GPS satellite system.

Levin and Enge developed a curriculum in which students, working in teams, use ViewSat to develop their own suggestions for the placement of ground stations. For each proposed location they must consider cost, atmospheric conditions, available technical support, environmental impact and political stability. In the process they learn about geography, mathematics, map reading, politics and world cultures.

A student project team successfully tested the curriculum with students at a middle school in Worcester. Levin says he and Enge will be seeking funding from the National Science Foundation and other funding agencies to help them get the idea into other schools.

Levin says ViewSat is an example of how well-designed software can lure students into wanting to know more about science and technology. It's a phenomenon he's frequently observed in his own lab. "Often, the better students will come up against a wall while using our software," he says. "They'll ask a question that the program can't answer. Then I've got my hooks into them. I'll urge them to work in the lab in the summer or do an MQP to add this new feature."

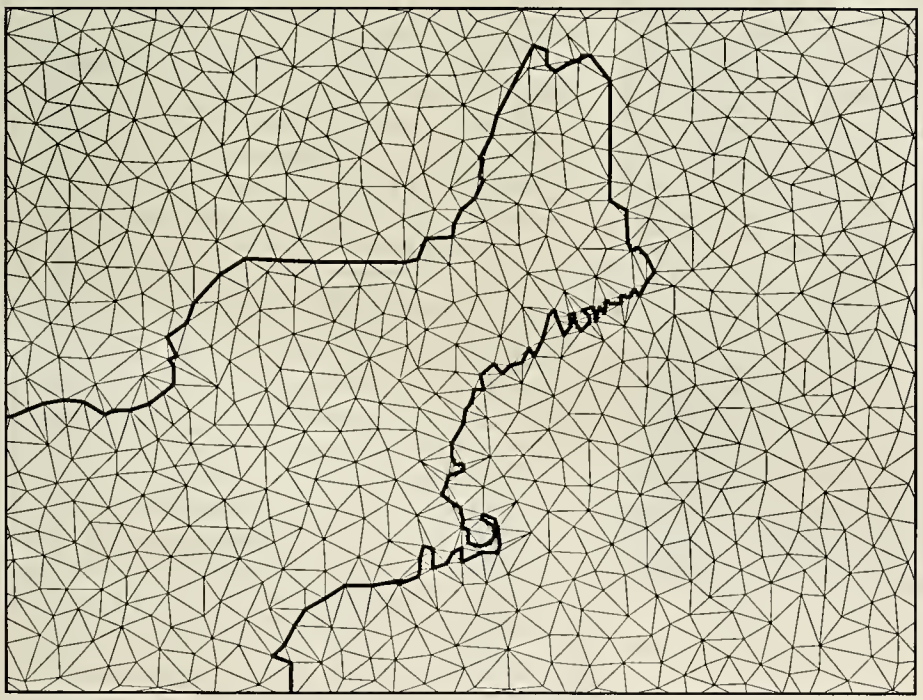
While Levin gets better programs out of such collaborations, he says the students gain far more. "They end up knowing almost as much as I do about numerical methods, about the process of developing large, research-oriented codes, about graphical interfaces and matrix-inversion routines, and about modeling some heady and sophisticated physical phenomena. They have to know these things to write and debug their programs."

One area of numerical analysis that currently has its hooks deeply into Levin is the study of inverse problems, a technique used to determine the properties of a material by observing how energy—such as sound or light—is transmitted through it. Examples of inverse problems are the use of sound waves to study subterranean geology and navigating with radio beacons.

Currently, Levin is working with Hong Gan, a graduate student in electrical engineering who is studying inverse problems in medical imaging systems that use ultrasonic energy. "This is the type of work that the PYI grant is helping make possible," Levin says.

Levin, who says he spends his rare free time outside of the lab and the classroom running, indulging his love of short-wave radio, or researching the implications of the Holocaust on the relationship between the German and Jewish peoples (a subject he hopes to write a book about someday), says the greatest benefit of the PYI grant may be the freedom it gives him to do more research himself.

"The only thing that's not satisfying about the success of the CFL," he says, "is that I no longer have the time to engage substantially in the actual process of software development. More and more, I'm the person who has to sweat the details of fund raising and administration. Growth breeds growth, and our financial requirements have increased by two orders of magnitude since we started the lab. But I suppose," he adds with a smile, "that's the kind of problem I can live with."



Andrew Hansen's mesh generator created this grid, used in a study of Loran C.

Thinking in Concrete Terms

JANET WOODCOCK

Through his work on asphalt and concrete, Tahar El-Korchi says he hopes to improve the nation's crumbling infrastructure.

While we take them for granted, our modern world is largely held together by seemingly mundane materials like concrete and asphalt. They coat the millions of miles of highways and roads we drive on, form the runways of our airports, and make up the foundations of our houses and the walls and floors of the buildings in which we work. The manufacture of these prosaic materials constitutes a multibillion-dollar industry, and the price tag for repairing the crumbling asphalt and concrete of the nation's infrastructure is estimated at well over $1 trillion.

For Tahar El-Korchi, assistant professor of civil engineering, the hard surfaces under our feet have always been more than passing interests. "My work has focused on the structure and properties of these various construction materials," he says, "But from a broader point of view, everything I do is aimed at improving the infrastructure. For me, that's what makes it interesting—it has a real purpose."

Over the past half decade El-Korchi has been applying modern scientific techniques and tools to the study of concrete and asphalt materials, employing electron microscopy to look at their microstructure and morphology, X-ray diffraction to study their compound composition, and mercury-intrusion porosimetry to investigate their pore structure. His goal is to understand how these materials form and how they fail, and to find ways to make them stronger, lighter and more durable. He is also working to develop ways to more easily and efficiently observe cracking in concrete and asphalt, techniques that could help contain the tremendous cost of maintaining the nation's roadways.

"People have been studying these materials from an empirical point of view for many years," he notes. "Now we're looking at them in a much more scientific way, and that's exciting. Part of the motivation is economics. People are realizing just how important these materials are and how much it costs when they fail. I think this is reflected in the fact that the National Science

Foundation is now awarding PYI grants to people in my field."

A native of Morocco, El-Korchi says he became interested in cement-based materials as a graduate student at the University of New Hampshire. For his dissertation, he examined the use of concrete to contain and stabilize hazardous industrial and municipal waste, a technique that could be an important step in solving the nation's significant waste disposal problems.

"Regulations preclude dumping hazardous waste prior to treatment," El-Korchi notes. "Essentially, you need to reduce the potential for contamination before ultimate disposal. One way of treating the waste is to solidify it with a cement-based material. The theory is if you can trap the pollutants in a solidified matrix, they won't dissipate into the groundwater."

In addition to providing a means to safely dispose of hazardous by-products, stabilizing waste in concrete could produce a useful construction material. In fact, engineers have considered using blocks of stabilized waste to make reefs and jetties. With this in mind, El-Korchi studied how long-term exposure to seawater might affect these concrete-waste composites.

He found that while some composites fare well in the ocean environment, others become unstable. For example, when a cadmium-concrete mixture is exposed to saltwater the material cracks and falls apart. El-Korchi discovered that chlorides in seawater dissociate the cadmium hydroxide that forms when cadmium is mixed with cement, essentially breaking the bonds that hold the material together.

While completing his master's degree at the University of New Hampshire, El-Korchi served as director of the New Hampshire Department of Transportation's Construction Materials Laboratory, which is based at the university. At that time the laboratory was working to develop more durable concrete with better mechanical properties.

"We were successful in improving the quality of the materials used in bridge decks, thus improving their durability in the harsh New Hampshire winters," he says. "To accomplish this, we had to better understand how concrete degrades. We did experiments where we simulated cycles of freezing and thawing and wetting and drying, and studied the effects of chemical deicers on the concrete."

In graduate school El-Korchi became interested in the relationship between the microscopic structure of concrete and its physical properties. This interest has become the foundation for much of his subsequent research. "As an example," he says, "microporosity—an indication of a material's strength and permeability (and, therefore, the tendency of water to seep into it) is a very important determinant of a material's performance. If you can reduce porosity and minimize the formation of hydration compounds like calcium hydroxide, you can improve durability."

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Graduate student Francisco N. Jimenez prepares to test an asphalt sample in a special environmental test chamber.

Concrete, El-Korchi notes, is formed by mixing cement, a grayish powder made from a complex blend of chemical compounds, with water and aggregate—usually sand and gravel. As the liquid cement dries, it binds to the aggregate and forms a solid matrix around it. The properties of this matrix depend on a number of factors, including the proportion of ingredients in the powder and how the cement binds to the aggregate.

If the matrix is too porous, water can get in and freeze. Porous concrete will also let in chlorides and sulfates from salt, which will begin to break down the chemical bonds that hold the material together. Eventually, induced tensile stresses will cause the weakened concrete to crack and spall. Though this ultimately happens to all concrete, adjusting the microstructure to reduce the intrusion of water and corrosive liquids can extend the normal lifetime of concrete from 15 to 20 years to at least 30 to 40 years.

Another factor that affects the life of cement-based materials is temperature, El-Korchi says. For example, when exposed to the constant temperature swings common in New England, concrete undergoes frequent cycles of contraction and expansion, which can eventually crack it.

To find out more about how temperature affects concrete, El-Korchi and Gary L. Leatherman, assistant professor of mechanical engineering, are studying samples of asphaltic concrete—a material used in airstrips—in a testing machine that exposes the samples to precise temperatures and mechanical stresses. The work is supported by the U.S. Army Corps of Engineers.

"We all know that pavement cracks, especially in cold weather," El-Korchi says. "The question is why? In this study we're employing some scientific techniques to better understand the failure mechanisms."

In the study, strips of asphaltic concrete supplied by the U.S. Army Cold Regions Laboratory in Hanover, N.H., are placed in a servohydraulic testing machine purchased with a grant from the National Science Foundation. The machine applies a force to the sample that simulates the stresses it might experience in actual use on a runway, while an environmental chamber around the sample keeps it at a constant temperature.

Using an electron microscope, El-Korchi has examined hundreds of samples that have been exposed to a wide range of temperatures, looking to see how the combination of mechanical stress and temperature exposure alters the basic structure of asphaltic concrete. The data will be used in a new generation of computer models that will predict how new types of concrete and asphalt materials will behave in actual use, eliminating the time and cost associated with laying down test sections.

Using glass fibers to make concrete stronger is the goal of another project on which El-Korchi and Leatherman have collaborated over the past few years.

"Concrete is a brittle material," El-Korchi says. "To improve its tensile strength you can add fibers to the concrete matrix. The idea is that as a crack propagates toward the fiber, the fiber will pull out of the matrix, absorbing the energy of the crack and protecting the concrete."

Various types of fibers, including steel, polymer and carbon, have been used to reinforce concrete, but their high cost has prevented this technique from gaining widespread acceptance in the construction industry, El-Korchi says. Glass fibers are comparatively inexpensive, but tend to decompose in the highly alkaline cement matrix. Alkaline-resistant glasses have been tried, El-Korchi says, but they seem to bind too tightly to the concrete, and therefore break rather than withdraw when a crack begins.

With a $30,000 grant from the National Science Foundation, El-Korchi and Leatherman are making concrete reinforced with fibers of a special alkaline-resistant glass known as oxynitride glass. They've found that unlike traditional alkaline-resistant glasses, oxynitrides don't form strong bonds with the concrete matrix. In fact, initial tests have shown that samples reinforced with oxynitrides are significantly stronger than regular concrete. The two researchers have applied for a $110,000 grant from the NSF to continue this work.

"Glass-fiber-reinforced concrete is currently being used in some building construction, but not as a load-bearing material," El-Korchi says. "For example, it's been used to make the outer wall panels of some tall buildings, but these panels are more decorative than structural. If the panels could be made strong enough to bear some of the load of the building, you could reduce the need for other structural supports and therefore lower building costs."

In other work supported by the NSF, El-Korchi is collaborating with researchers at Brown University to look at the possibility of using embedded glass fibers to monitor the internal state of concrete. Already, optical fibers—similar to the glass fibers that carry data over telephone and computer networks—have been employed as temperature and stress sensors in composite materials used by the aerospace industry.

If similar fibers could be successfully incorporated into concrete, they could be used to detect microcracking, chemical reactions and other physical changes that could provide an early warning of deterioration. The idea, El-Korchi says, is to enable engineers to better plan maintenance and replacement work by continually monitoring the condition of structural concrete.

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El-Korchi with a system that processes images of pavement cracking. On the left screen is a complete pavement image; the aggregate has been removed from the image on the right, highlighting the cracks.

In the work with Brown, which is still in its early stages, El-Korchi and a team of graduate and undergraduate students will make concrete samples with embedded optical fibers. While the WPI team studies how the fibers interact with the concrete matrix, and whether these glass fibers can survive long-term exposure to the chemicals in the concrete, researchers at Brown will attempt to correlate changes in the characteristics of a beam of light passing through the fibers with specific chemical or physical changes in the concrete.

Studying the condition of concrete with light waves is one example of how the techniques of nondestructive evaluation may one day help to more accurately and economically monitor the nation's infrastructure. In another project under way at WPI, an interdisciplinary team consisting of El-Korchi, Michael Gennert and Matthew Ward, both assistant professors of computer science, and Norman Wittels, adjunct associate research professor of civil engineering, is using video imaging to detect cracks in asphalt pavement.

The goal of this research is the creation of an automated system that will one day analyze images of the millions of miles of

U.S. highways and rate each section according to its need for repairs or upgrades. The system will allow states to more systematically allocate highway maintenance funds.

"Currently, this task is done by highway engineers who examine each mile of highway and make notes about its condition on a standard form," El-Korchi says. "This is a highly subjective process, which is why the Federal Highway Administration wants to automate it. The idea is that you'd place a camera on top of a truck and record video images as you drive along. A supercomputer would then process the images and categorize the features it sees."

Such a system could be programmed to detect the different types of surface cracking (a phenomenon highway engineers call pavement distress) that can occur in roadways. Some crack patterns are indicative of damage due to temperature exposure, others of the effects of subsurface changes, and others of drainage problems.

"This seems like a simple problem, but it's actually a very difficult technical challenge," El-Korchi says. "First of all, you are talking about huge amounts of data. And, more important, you're talking about a system that must be able to distinguish distress from shadows, sand, road kills and so on, and one that must do so in all climates and under all types of lighting conditions."

For the past three years, the WPI team has been attempting to solve one of the major problems that has, to date, stood in the way of developing such a system. Currently, image processing systems have a difficult time identifying distress in pavement images because the signal produced by aggregate—the stones and other granular material mixed with asphalt—overwhelms other elements of the picture.

The problem is analogous to trying to look through the glare on the surface of a pool to see what's on the bottom. One solution is to put on polarized sunglasses. The polarizing filters in the lenses screen out the light rays bouncing randomly off the ripples in the water surface, thus permitting a clear view of what's below the surface.

Using an image processing technique known as relaxation labeling, the WPI researchers have developed the equivalent of polarized glasses for their computer: mathematical expressions that enable the computer to recognize the characteristic signatures of aggregate and then filter out this part of the image. When this background noise is eliminated, the pattern of distress can be more easily identified.

"If we can develop a universal set of rules that reliably identify aggregate in these images, we can throw out a good portion of the data and concern ourselves just with the cracks," El-Korchi says. "This should reduce the time and money needed to analyze pavement images." The team has applied for $100,000 from the Strategic Highway Research Program to continue this work.

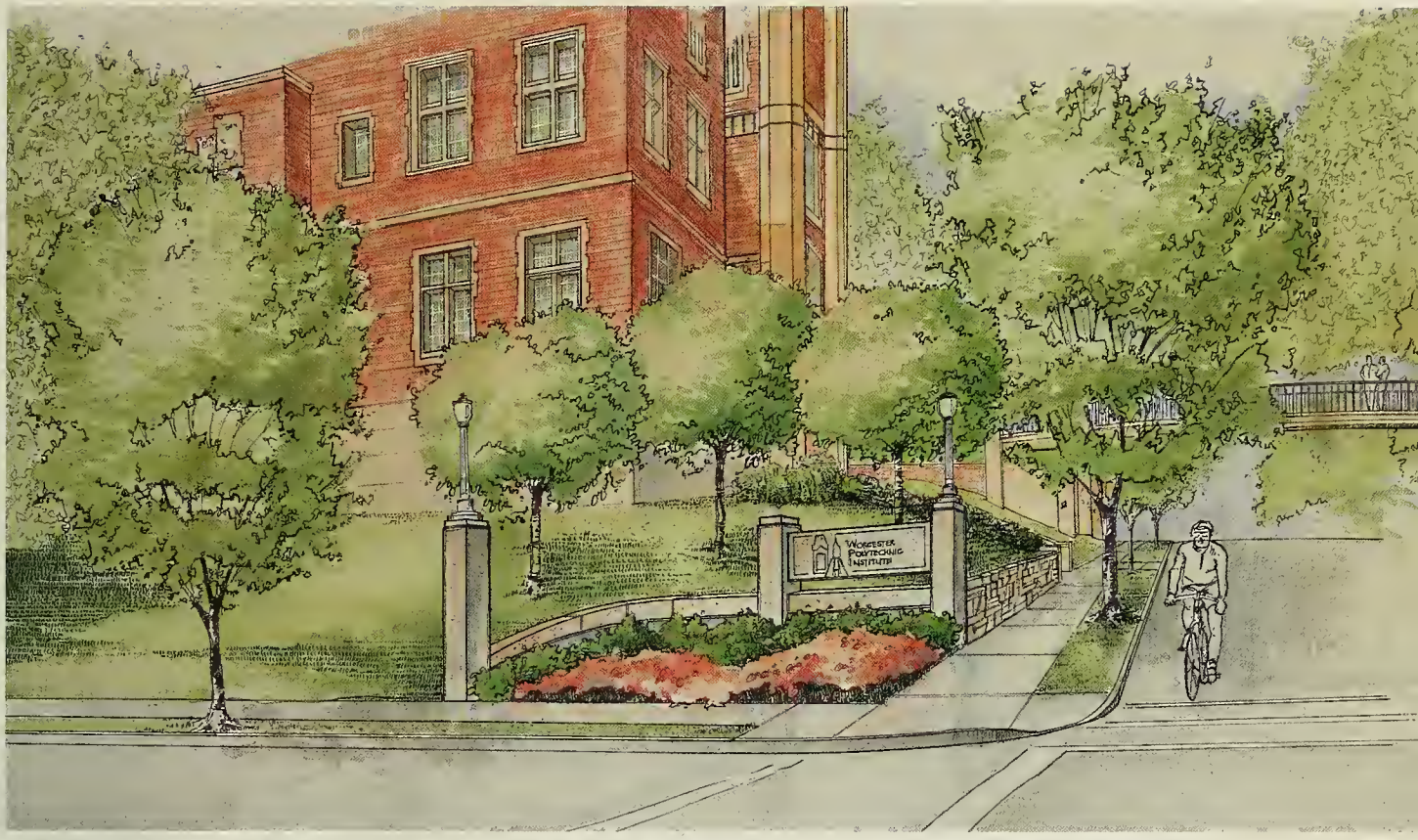
El-Korchi says the pavement distress project is an example of the interdisciplinary nature of the study of construction materials. "In this field you have to have a broader background than researchers in many other areas of civil engineering. Part of the reason for my success is my ability to cross the barriers between civil engineering and other disciplines, such as materials science and computer science."

El-Korchi says the multidisciplinary aspects of his field have also enabled him to explore a broad range of research topics. "As a researcher, you try to look at all sorts of things that are not necessarily related," he says, "because you're trying to get research funding and because you're looking for ways to build collaborations with other researchers. Once you obtain funding, you can concentrate on one area. I'm hoping that the PYI grant will help me focus my research objectives and develop my expertise."

JANET WOODCOCK

PLANTING A SEED

The Institute Launches a New Plan to Endow the Maintenance of Its Campus



CAROL R. JOHNSON & ASSOCIATES

The master plan for the WPI campus is a vision of what the grounds can become with the help of alumni and friends. Opposite, the West Street and Institute Road intersection as it looks today; the artist's rendering above shows it as it will appear when it is transformed into a more formal campus gateway. Below, the grounds around Alden Memorial will be completely refurbished in the year ahead.

JANET WOODCOCK

On a bright April morning a car pulls into the visitor's parking circle off West Street. The doors open and out step a young student and her parents. As they walk together to the Admissions Office, the student looks around anxiously.

Immediately she notices the elegant brick facade of Alden Memorial and the massive globe of copper-colored leaves on the nearby beech tree. As she approaches the gentle rise of Earle Bridge, a wedge of bright spring flowers catches her eye. Across the way she sees the Gothic splendor of Boynton Hall with its coarse granite facade and stately clock tower. Before she reaches the front door, she turns to admire the sinuous, tree-lined drive that slopes gracefully down Boynton Hill.

For most prospective students, this first look at the WPI campus leaves a powerful and lasting impression. "An applicant might never see a labora-

The master plan developed by Carol R. Johnson & Associates includes campus improvements that will cost about $1.3 million. These will be completed in sections as the necessary funds are raised. Planned improvements to a few outlying areas of campus are not shown above.

tory or meet a professor, but he will park in a parking lot and walk down a sidewalk or path with his parents," notes John E. Miller, associate vice president for business affairs and director of physical plant. "If the campus looks appealing, he's likely to conclude that this is a good school."

The positive effect an attractive campus can have on potential students is one of the most important reasons WPI will spend about $450,000 next year to maintain its grounds. The campus also plays a role in shaping the impressions of the thousands of other visitors who come to WPI for conferences and special events, such as Commencements and Reunions. And, of course, the trees, flowers and other visual elements that make up the grounds form a cheerful backdrop to the bustle of day-to-day life at a college, making the Institute a more inviting and pleasant place in which to work and study.

"The campus is really a vital part of what makes WPI special," Miller says. "We are fortunate to have beautiful grounds surrounded by attractive parks and neighborhoods. Our grounds crew tries very hard to keep the campus looking its best, but in these days of shrinking budgets, funds for campus beautification projects often don't fall into the high-priority category."

As budgets have grown tighter at WPI in recent years, the college has had to scale back its groundskeeping efforts. After growing by about 50 percent over the past six years—a deliberate move aimed at enhancing the campus's appearance in a time of heightened competition for new students—funding for upkeep has leveled off. "Last year we spent almost exactly what we spent the year before," Miller says. "This year our budget will remain about the same."

In these leaner times some projects, such as tree pruning, must be curtailed, while ways are found to do other jobs more economically. For example, the college is planting more perennial flowers, which bloom year after year, and fewer annuals.

JOHN REIS

JANET WOODCOCK

JANET WOODCOCK

The goal of the master plan is to build upon the existing beauty of the WPI campus, which benefits from about $450,000 in grounds work each year. Existing plantings accent Sanford Riley Hall, above, top, and the sundial in front of Boynton Hall, above, bottom, among other areas. One of the plan's principal opportunity zones is the refurbishment of Freeman Plaza, left. The plaza was built in 1977 as a gift of Howard Freeman '40 and his wife, Esther.

"The campus is really a vital part of what makes WPI special."

JANET WOODCOCK

JANET WOODCOCK

JANET WOODCOCK

Gifts from alumni and friends have already endowed the maintenance of several areas of the campus. A plot near the Washburn Shops, right, top, was endowed in memory of Harvey Channin, a gardener employed by Milton Higgins. The plantings that adorn the main entrance to Higgins Laboratories, above, were endowed by former WPI president Edmund Cranch, his wife, Virginia, and friends of the couple. A recent special project of WPI's groundskeepers enhanced the beauty of the Higgins House gardens, right.

Recognizing the need to ensure that WPI will always have adequate funds to keep up and continually improve its grounds, the college has launched a new initiative to endow the perpetual care of the campus.

The program was inspired, in part, by a suggestion from Edward S. "Ted" Coe '31, who has asked that his own gifts to WPI, which total more than $63,000, be designated for future grounds use—in particular, for the purchase of new trees. "Ted's interest served as a catalyst to encourage new discussion of a plan that has been on the back burner for some time," says Donald F. Berth '57, vice president for university relations.

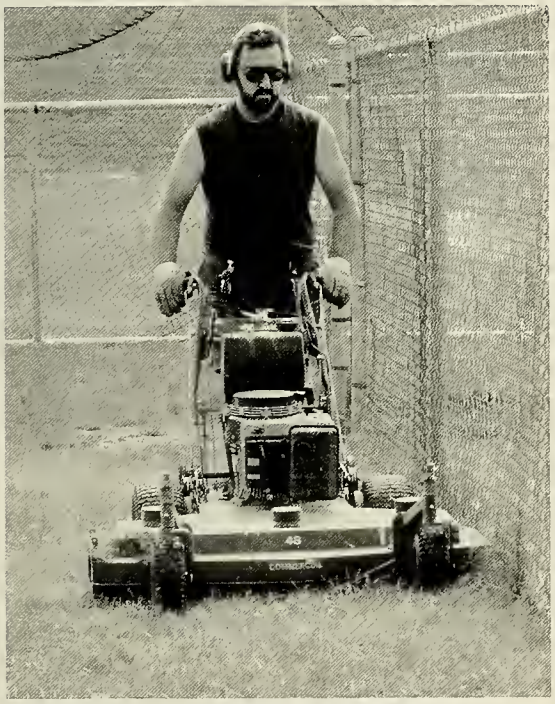
As a critical first step in that program, the college hired Carol R. Johnson & Associates, Cambridge-based landscape architects and site planners, to prepare a master plan for the campus. The plan has several goals, the most important of which is enhancing the visual quality of the campus, particularly in such highly visible areas as primary entrance points and well-traveled walks.

The plan also aims to create a coherent character for the campus by giving a consistent look to plantings, benches, lights and so on, while still allowing individual areas unique identities. Other goals include improving environmental quality, comfort and pedestrian safety, and reducing the amount of work and money needed to maintain the grounds.

While the plan covers most of the campus proper, six "principal improvement opportunity zones" are singled out:

- A new campus gateway with concrete walls and stone light piers at the intersection of West and Salisbury streets, along with general planting improvements adjacent to the academic buildings along Salisbury Street.
- A similar gateway at the Institute Road and West Street intersection, along with new trees along West Street, scored-concrete crosswalks, and other general improvements. Together, these new gateways will give a more stately and distinctive look to the two primary entrances to the campus.
- The refurbishing and upgrading of Freeman Plaza, a popular gathering spot for students and faculty. Completed in 1977, this mall is beginning to show its age. To restore and enhance its appearance, existing concrete will be replaced with new brick, concrete and granite paving; new retaining walls, benches, trees and plantings will also be installed.
- A significant upgrade of the walkway that runs from West Street behind Higgins Laboratories and Alumni Gym. When combined with a scored-concrete crosswalk on West Street, the area will become an extension of Freeman Plaza. This project will also include new lighting and benches, and improvements to the paths between this area and Higgins House.
- An upgrade of the small parking area behind Boynton Hall and the walkway that runs between Stratton Hall and the Washburn Shops, including more attractive paving materials and enhanced plantings.
- And, general improvements to the walkways, plantings and benches along the northeast service drive near Atwater Kent and Fuller laboratories, including a realignment of the roadway to improve safety.

MICHAEL DORSEY



Maintaining the campus is a full-time job for George "Roy" Desmarais and the rest of WPI's groundskeeping crew.

The general goals of the plan include enhancing the periphery of the campus to improve its visual impact; upgrading items like benches, railings, fencing, lighting, signage and plantings to enhance the general character of the campus; making the campus more attractive and inviting to pedestrians; enhancing the movement of cars around the campus; and using plants to screen unsightly elements like transformers, service areas and parking lots.

"Together, these improvements will cost about $1.3 million," Berth says. "However, we have divided the overall plan into distinct areas that present gift or memorial opportunities ranging from $500 to $50,000. These amounts, by the way, will fund not just the projects, but the perpetual maintenance and occasional upgrading of the newly landscaped areas. We will attack elements of the plan as funds are raised to finance them."

The first area likely to be completed is the triangular expanse between Alden Memorial and Sanford Riley Hall. The project, part of the Alden renovations now in progress, will transform this little-used space into an inviting plaza through the creative use of plantings, benches, paving and lighting.

Endowing the maintenance of the campus is not an entirely new idea. Over the years WPI has received gifts to endow specific areas of the grounds. For example, the garden plots in front of Higgins Laboratories were endowed by friends of former WPI president Edmund Cranch and his wife, Virginia, and by the Cranches themselves. A plot near the main entrance to the Washburn Shops and Stoddard Laboratories was endowed in memory of the late Harvey Channin, a professional gardener employed by former WPI board chairman Milton Higgins. Upon its graduation, the Class of 1983 gave funds to landscape the east side of the Washburn Shops. Perhaps the largest designated landscaped area is Freeman Plaza, given by trustee Howard Freeman '40 and his wife, Esther.

"This is how we envision the campus beautification program working," says Berth. "Alumni and friends may adopt particular areas of the campus, perhaps favorite spots from college days. A large map illustrating the various giving opportunities now hangs in the tower entrance of Boynton Hall. As they are funded, endowed areas will be noted on the map and the names of the donors inscribed on plaques set in the endowed areas."

"We see this plan as a vision of what the campus can and should be," Miller says. "We hope it's a vision our alumni and friends will share."

Beating the Odds

By Roger N. Perry Jr. '45

When World War II closed his school, Martin Bromberg '51 took charge of his own education. When language and cultural barriers got in the way, he struggled back and earned top honors at WPI. And when his country began making automobiles, he chose to build a product no one else could. Today he is chairman of the largest maker of carburetors in the Southern Hemisphere.

Martin G. Bromberg '51 knew it wouldn't be easy when he arrived in Worcester in 1947 to begin his studies at WPI. English was not his native language. His preparatory schooling had been informal. And he was more than 6,000 miles from his home in São Paulo, Brazil.

Despite the obstacles he had to overcome to earn it, Bromberg says he is thankful for his WPI education, which he credits for much of the success he has enjoyed as a manufacturer and a businessman.

Now semiretired, he is chairman of the board of Indústria e Comércio Brosol Ltda., a company he founded 30 years ago with $200,000 in U.S. dollars. From a firm with just three employees, Indústria e Comércio Brosol has become the largest maker of carburetors and fuel pumps in the Southern Hemisphere. The corporation today employs more than 2,400 people and records annual sales of about $130 million.

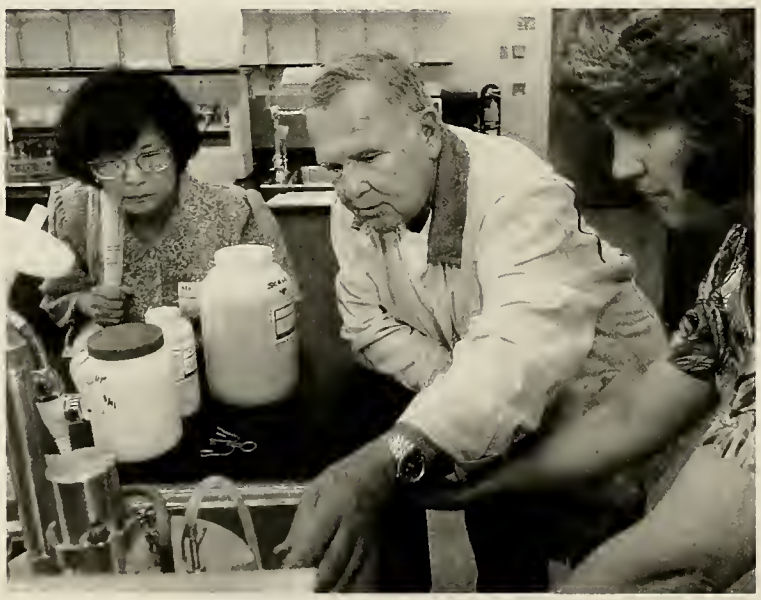
Bromberg says his family has a long history of business success in Brazil. "Bromberg & Company, our family business, was started in 1863 by my great-grandfather, who had arrived from the Alsace-Lorraine region between Germany and France about 1825. When the company began, it was an importer of hardware, tools and machinery. It later expanded throughout Brazil, building factories, mills and railroads."

Born in Hamburg while his mother was visiting Germany, Bromberg attended schools in São Paulo and then completed his service in the Brazilian army before enrolling at WPI. He says his preparation for WPI was limited in part because Brazilian schools offered few courses for prospective engineers. "There were schools for people who wanted to be scientists," he says, "but not for those aspiring to be practical engineers. One of the courses they taught was astronomy for mechanical engineers!"

Bromberg says the tendency for ethnic and national groups in Brazil to form close-knit, segregated communities would also prove an impediment to his education. "Brazil welcomed immigrants, but unlike the United States, it was not a melting pot. When I was a boy, ethnic national groups didn't mix much, although it's not so much that way anymore. The Germans and the Italians, for example, had their own clubs and their own schools. I went to a German school so I could continue my studies in Austria, Switzerland or Germany. My father had studied in Germany and my grandfather in Switzerland."

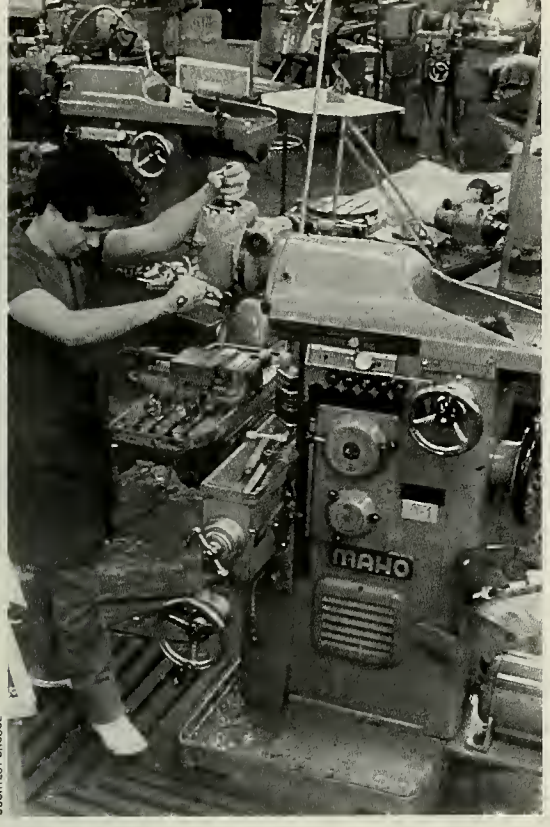
When World War II began, Brazil closed the German schools and the U.S. government placed the family's business and other Brazilian firms that imported products from Germany on a blacklist. "So," Bromberg says, "at age 14 my formal schooling ended."

Many of the German teachers who found themselves out of work when the schools closed were unable



JANET WOODCOCK

Bromberg and his wife, Massume, left, tour WPI's new Bioprocess Laboratory with Pamela Weathers, associate professor of biology and biotechnology.



COURTESY BROSOL

Above and below, interior and exterior views of Brosol's Ribeirão Pires complex.

to return to Europe. Most supported themselves by taking factory jobs. Bromberg says he was able to continue his education by studying with some of these educators. "For instance," he says, "when I was 14 I had a teacher in descriptive geometry. He was working in our factory as a draftsman because he had to survive in some way or other."

Since he was unable to complete his formal education, Bromberg did not qualify for admission to the Brazilian university. His uncle, Leon Skuropat, a 1932 graduate of WPI, urged Bromberg to apply to the Institute.

"My uncle was then the manager of General Electric Co. in Brazil," Bromberg says. "He helped me write to WPI to find out if I could go there with a secondary education that had no official recognition (I had studied with private teachers and by correspondence). Dean [Jerome] Howe must have been impressed, because I was admitted."

Bromberg says he was unprepared for the style of teaching he encountered at WPI. "The professors would put on the blackboard what you were supposed to read and which problems you were supposed to solve," he says. "Then, when you came to class with everything answered, they would ask you why you did it this way or that way. There were blackboards all around the room and everyone had to put his solution on the board and discuss it.

"This was new to me—the idea that you could learn something yourself before someone taught it to you. It took me a while to catch on to the system; in my freshman year I had to take make-up exams in mathematics and chemistry. But before I graduated I had the satisfaction of earning second honors and, later, first honors."

Bromberg says he remembers how several of his professors went the extra mile to help him get through his difficult first year, when he not only had to make the transition to college, but overcome language and cultural barriers, as well. "I'll never forget how Professor [Richard] Cobb helped restore my confidence when I was failing math that first year. It's still a wonder to me that a professor would spend so much time to help one student."

Bromberg says physics professor Morton Masius provided a different sort of inspiration. "One day he called me into his office and said, 'You seem to be one of those South American playboys and I think you will not make it here at WPI.' This made me work all the harder, and I earned first honors in my senior year. When I received my diploma, Dr. Masius was the first one to congratulate me."

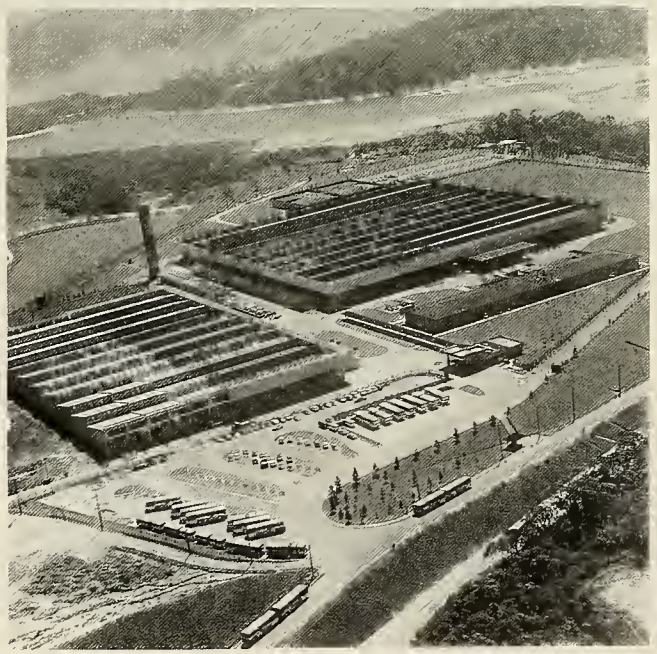
During summer vacations Bromberg took courses in business administration at the University of Wisconsin and later applied those credits toward a degree in business administration in Brazil. He also earned a master's degree in safety engineering and a doctorate in engineering administration from Pacific-Western University.

The Ph.D. program was tailored for busy professionals, Bromberg says. Considering the credits he had already earned in mechanical engineering and business, the college worked out a unique program for him. "They gave me reading assignments and I wrote papers that I sent back to them," he notes. "The reading list was interesting because I had to read a lot of books I didn't know about. One that impressed me very much was *Small is Beautiful* by Ernest F. Schumacher."

After he graduated from WPI, Bromberg returned to Brazil to join the family business, which by then had switched from importing to manufacturing machine tools. At about that time Brazil passed a law that required companies to guarantee job security to anyone who had been employed for at least 10 years. "Before that, if you laid someone off, you had to pay him one year's salary for each year he had worked," he says. "After 10 years you had to pay him at least two year's salary for each year, if he agreed. If he didn't agree, you had to keep him on the payroll forever."

Bromberg did some calculations showing that, under this law, the company's potential liability to its employees was greater than its total capital. He urged his father and his uncle to close the business, pay off the employees, and look for something else to do.

"A fine thing. We send the boy to America to go to college and he comes back and tells us to get out of the business," Bromberg remembers his father saying. "But they went over the figures," he says, "and decided to sell everything. That law was later changed. Now the system is similar to the Social Security system in the United



COURTESY BROSOL

JANET WOODCOCK

States, in which employers regularly pay a part of each worker's salary into the system."

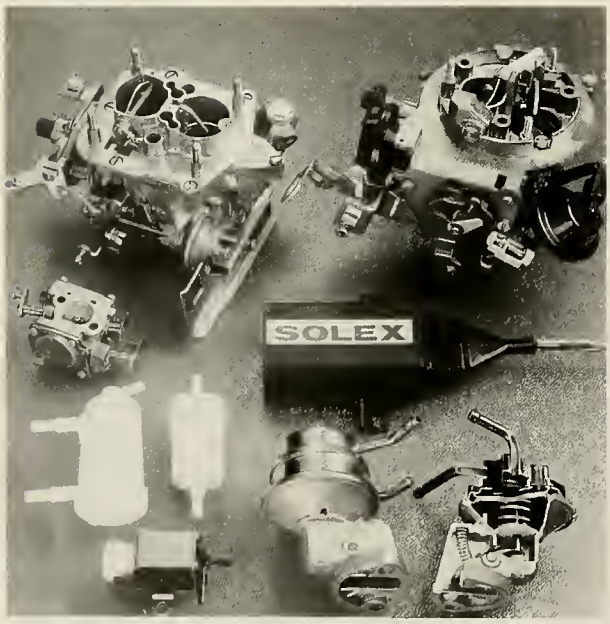
In 1959, as Brazil began to develop its own automobile industry, Bromberg started his own company to make parts for the auto makers. "I decided to make carburetors," he says. "I thought this would be a good product since they were hard to make and nobody else wanted to produce them. It was precision work of a type unknown in Brazil, and nobody had any experience with it. I figured this would be a chance to do something that no one else had done so far."

Bromberg traveled to Germany to get a license to make the famous Solex carburetors in Brazil. He learned, to his surprise, that Solex is a French company that had licensed the manufacture of its fuel pumps to German firms. In the end he was able to obtain a license to make carburetors *and* fuel pumps.

"That's how Indústria e Comércio Brosol Ltda. began," he says. "Since then we have expanded the product line to include water pumps and some antipollution valves and controls for cars. For example, we don't make catalytic converters, but we make the valves to purge them. We also make such things as electrical valves to control air-conditioning units.

"Because I went to WPI, I was able to design and have manufactured most of the equipment we used to make our products. I've even made machines in my own tool shop."

Most recently, Bromberg says, he's converted his company's machining units from a mechanical to an electronic base. Now drilling, boring and reaming processes



COURTESY BROSOL

are controlled by counting the number of rotations made by step motors. "All I have is a program in the microcomputer that tells the unit what to do," he says. "I tell it to go rapidly so many turns and then go slowly to the correct position. After the machining operation is done the program tells the unit where to move to complete the next step."

Today, Bromberg says, those programs are contained on printed circuits in the control units of the machining units. Ultimately he says he would like to be able to place the machining instructions on cassettes that can be inserted in the control units. That way, each time drawings are produced for a new part, a cassette can also be created that will tell the machines how to make it.

"By streamlining our production methods we've been able to reduce our work force from 3,200 to 2,400," he says. "This is a more manageable size for our company, sort of in keeping with the philosophy of *Small is Beautiful*."

As a businessman, Bromberg says he has come to appreciate the great need for better education in Brazil, a country where half the population can neither read nor write. "Raising the literacy rate is a priority goal for our country," he says. "In higher education, too, there is room for improvement. While the universities are getting better all the time, our professors are still underpaid. They have to do a lot of consulting just to survive, so they can't devote enough time to their students."

Far left, some of Brosol's products; center, Bromberg meets with WPI President Jon C. Strauss during Reunion weekend; below, Bromberg and classmate G. Albert Anderson march in the Reunion parade.

acumen that has helped make his company among the most successful in Brazil. While touring the college's new Bioprocess Laboratory, he spotted a technology that might be put to work back home, as well as a way to build a mutually beneficial bridge between his alma mater and his native country.

"The fermentation process I saw there looks like something that might have application in Brazil," he says. "Ours is the first country to run cars on alcohol made from sugar cane. I'm no chemist or chemical engineer, but I think this work at WPI is something we in Brazil should know more about."

Perry is senior writer for Quest, *the Institute's development newsletter.*

One of the consequences of having overworked and underpaid instructors, Bromberg says, is that colleges in Brazil permit too many students to get degrees without working hard. "At WPI we did lab experiments in teams of four or five students. We did the experiment as a group, but then everyone had to do his own report. In my country, due to a certain laziness, or perhaps due to lack of time, they let as many as six students do the experiment, but only one writes it up. That way only one works and the others float along. That's wrong as far as I'm concerned."

While Brazilian universities—private and public—charge a fraction of the tuition paid by most students in the United States, they also have less (and less sophisticated) equipment. "In Brazil, education is classroom-oriented rather than laboratory-oriented," Bromberg says. "We are just now getting computers into the schools because the computer industry recognizes how important today's students will be as tomorrow's customers."

Bromberg's three children all have attended Brazilian universities. Sabine earned a degree in business administration in 1989. Thomas, who received his degree in mechanical engineering last December, works for one of the companies owned by Bromberg's firm. And Robert is studying to be an architect.

Bromberg returned to WPI in June for the first time since 1951 to attend his 40th Reunion. During his visit, he demonstrated some of the business

JANET WOODCOCK

The *WPI Alumni Association:*

100 Years and Counting

By Ruth Trask

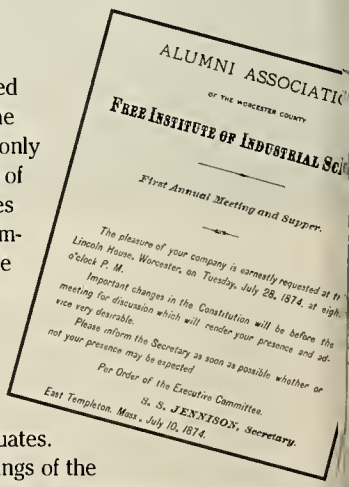
While the WPI Alumni Association dates its birth as an official corporation to 1891, the organization was actually founded nearly two decades earlier. Meeting in the chapel on the third floor of Boynton Hall on July 30, 1873 (just two years after the college sent its first graduates out into the world), a handful of alumni got together and laid the groundwork for an association to represent their interests and to serve as a liaison between the college and its graduates.

Edward Tolman

At that first meeting the new association adopted a constitution and elected its first officers. Edward F. Tolman, a member of the Class of 1871, became the first president. His classmate, Henry P. Armsby, was named one of three vice presidents; the others were Parkman T. Denny, Class of 1872, and Lucius B. Morgan, Class of 1873. Samuel S. Jennison, Class of 1871, was elected secretary, and Walter M. Wheelock, Class of 1873, took on the duties of treasurer.

By the time its annual meeting was held a year later, the new association was already prepared to make a major recommendation on behalf of its constituency to the WPI Board of Trustees. The group requested that, henceforth, all graduating seniors be awarded—at Commencement—bachelor of science degrees.

The recommendation stemmed from dissatisfaction over WPI's practice of awarding members of the college's early classes diplomas and not actual degrees. The diplomas bore witness to the fact that each student had faithfully completed WPI's full course of study and noted that the faculty and trustees were satisfied that the recipients were fit to engage in practical service. However, to receive a bachelor's degree a graduate had to complete four years of satisfactory employment in his field. The trustees reacted favorably to the proposal. Not only were bachelor of science degrees awarded at commencement the following year, they were conferred retroactively upon all previous graduates.



ALUMNI ASSOCIATIO

OF THE WORCESTER COUNTY

FREE INSTITUTE OF INDUSTRIAL SCI

First Annual Meeting and Supper.

The pleasure of your company is earnestly requested at t
Lincoln House, Worcester, on Tuesday, July 28, 1874, at eigh
o'clock P. M.
Important changes in the Constitution will be before the
meeting for discussion which will render your presence and ad-
vice very desirable.
Please inform the Secretary as soon as possible whether or
not your presence may be expected.

Per Order of the Executive Committee.

S. S. JENNISON, Secretary.

East Templeton, Mass., July 10, 1874.

Early meetings of the Alumni Association were devoted to the business of shaping the new organization's governing structure. It was not unusual for the bulk of these sessions to be consumed with discussions of new constitutional amendments. To close out each meeting, the association asked representatives of the

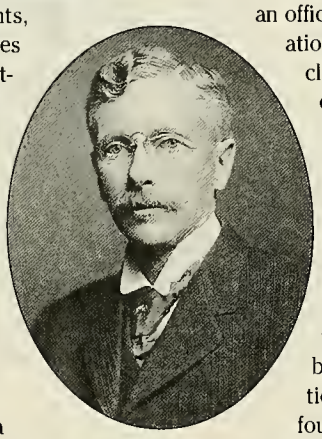
EDITOR'S NOTE: *The WPI Alumni Association marks the 100th anniversary of its incorporation this year. In this article alumni news editor Ruth Trask looks back more than a century to the association's origins, traces its growth, and lifts the curtain on the future of this nearly 20,000-member organization.*

The serving staff await the guests for the Alumni Association Dinner in 1901.

faculty, the trustees or the alumni to speak during dinner, and the talks often lasted far into the night. Beginning in 1877, the association invited members of the graduating class to be its guests at these annual spring dinners.

Eight years after they first gathered together, the Institute's alumni launched their first organized attempt at fund raising. In 1881 a subscription was launched to solicit the money needed to have a portrait painted of WPI founder John Boynton. The portrait, which has long hung in Alden Memorial, was presented to the college at Commencement in 1884. In 1886 a drive was begun to build an endowment, named for Charles O. Thompson, WPI's first president, to be used to purchase books for the library.

By the end of its second decade, the association had become an important presence on campus. In 1882 Henry Armsby, one of its original vice presidents, was invited to address graduates from the Commencement platform. The tradition continues today, with the association president speaking to graduates each year. (Armsby, who became one of the world's best known experts on animal nutrition, received the college's first honorary degree in 1921.)



Henry Armsby

In 1885 the association earned three seats on the college's Board of Examiners, a panel of engineers, businessmen and educators before whom candidates for graduation were required to appear. For a time the board also examined the graduates' senior theses and made a report to the Institute. In 1891 Charles G. Washburn, a member of the Class of 1875, became the first alumnus elected to the Board of Trustees.

For its first 18 years the WPI Alumni Association had been run somewhat informally. However, in early 1891, following three years of discussion, the organization adopted a new constitution and a new set of bylaws, setting the stage for its formal incorporation under Massachusetts law, a milestone that occurred on May 20 of that year.

The association's first decade as an official corporation saw the creation of the first regional alumni clubs. The clubs, primarily social organizations, were founded by alumni around the country interested in meeting and interacting with their fellow graduates.

The first of these, actually founded about a year before the incorporation of the association, was a formal branch of the Alumni Association in Washington, D.C. Within four years similar clubs had been formed in Cleveland and in the western states. The Philadelphia and Pacific Coast clubs were organized in 1895, the New York club in 1898, and the Boston club in 1899. Alumni clubs continued to pop up around the country as the new century began. In the early part of the 1900s groups were established in Schenectady, Worcester County, Western

In 1914 WPI beat RPI in the first football game played on Alumni Field, built through the generosity of WPI alumni.

New York, Detroit, Pittsburgh, the Connecticut Valley and Rhode Island.

Having formalized its goals and its organization, the Alumni Association set about expanding its fund-raising objectives. In 1910 the association inaugurated a permanent fund as a depository for the dues paid by alumni to earn life memberships. By 1912 the fund, having grown to about $3,600, was converted to an endowment for student aid. For two decades thereafter many students were assisted by loans from the fund, which was eventually transferred to the Institute.

Around this time the association took on a major challenge—helping the college build a modern facility for athletics. In its early years the college provided students with rudimentary athletic equipment in a grove of trees near the Washburn Shops, and the physical education facilities had not improved dramatically since then.

Sparked by a $1,000 challenge gift from the Class of 1901, the association developed plans to build an athletic field and a gymnasium. By 1913 it had raised $200,000 toward that goal. The college was eyeing a recently acquired 12-acre parcel of land along Park Avenue as a site for the field, but a small triangle of property owned by the Worcester Art Museum stood in the way. The association not only purchased the triangle, but, with the strong urging of Charles Washburn, agreed to pay for the other 12 acres as well. It also consented to pay $3,000 each year into an endowment for the maintenance of the field and gym until the fund reached $60,000.

Herbert Taylor was the first full-time secretary of the Alumni Association.

Alumni Field was completed in 1914 and the WPI football team beat RPI in the first game played there (it was the team's first win in two years). During graduation ceremonies in 1915, Alumni Association president George Rockwood '88 gave a dedicatory address beside the cornerstone of the partially constructed Alumni Gymnasium. Said Rockwood, "We are going on with the building until the funds give out." The gym was completed the following year.

JANET WOODCOCK

Robert Dietrich, left, presents the Class of 1917 Cup to Walter Abel '39, center, and C. John Lindegren Jr. '39, in 1989.

William Ames encouraged Herbert Taylor to write WPI's first history.

Donald Smith '41 took on the duties of alumni secretary after Taylor's death.

In 1914 the Class of 1894 presented the Alumni Association with a huge silver cup to be awarded to the class with the best attendance at the annual graduation dinner. The Class of 1874, celebrating its 40th reunion, was the first class to receive the cup. A second attendance cup was donated to the college in 1948 by the Class of 1917. This is the award still presented each spring to the class with the largest percentage of its living members in attendance at Reunion.

By 1919 the Alumni Association was becoming a grand old institution. Having served the college and its graduates for some 46 years—28 of them since its incorporation—the association decided the time was ripe to seek greater representation on the Institute's Board of Trustees.

Around that time a bill was approved by the Massachusetts Legislature permitting the expansion of the board from 15 to 30 members, including 15 term members (three to be appointed each year to five-year terms); these would be nominated by the association. "To this day the Alumni Association is granted the opportunity to propose 15 alumni for seats on the board," notes Stephen J. Hebert '66, current secretary-treasurer of the Alumni Association. "This is a reflection of the Institute's confidence in the abilities of its graduates and in the strength to be gained from 'family'."

The 1920s would prove a time of significant change for the association. In 1921 the organization began to debate the merits of creating an alumni council to give rank-and-file alumni more say in the operation of the group. A move in that direction occurred in 1923 when the association's governing board, the Executive Committee, was expanded into the General Committee, made up largely of representatives of the regional clubs. The General Committee evolved into the current Alumni Council in 1927.

In 1921 consideration was also given to making the part-time position of alumni secretary a full-time job, rolling into the job description the editorship of the *WPI Journal*, the duties of alumni treasurer, and the management of an employment service. The opportunity to make the change arose that year when mathematics professor Arthur D. Butterfield, Class of 1893, chose not to accept re-election to the post. Instead, the association decided to give the idea more thought.

When Herbert F. Taylor '12 accepted the position of alumni secretary in 1921, it was still a part-time job, but within a few years he would become the first person to hold that post full time. Taylor graduated from WPI with a degree in civil engineering and joined the WPI faculty in 1920 after working for the Northern Pacific Railroad, the city of Cleveland and a national consulting firm, and then serving overseas with the U.S. Army in World War I.

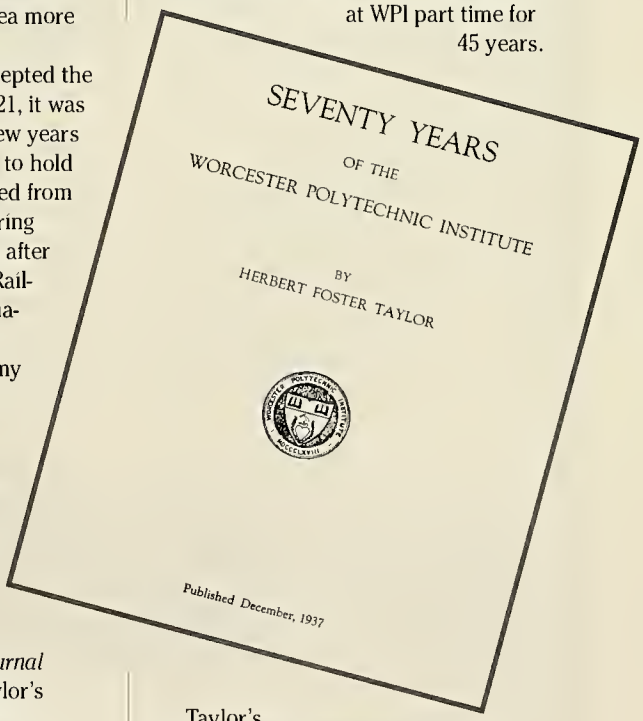
In short order Taylor showed himself to be an exceptional editor. "With a flair for editorial writing and a nice appreciation for the value of collegiate and alumni news, he soon made the *Journal* one of the best edited and most useful college magazines in the country," the *Journal* would report in a summary of Taylor's career following his death in 1946.

Taylor also organized a placement bureau for WPI and made it a thriving office. As the country fell into the Great Depression in 1929, Taylor's quiet but tireless efforts to find employment for graduates in those desperate years would win for him the undying gratitude—and for the Institute, the unswerving loyalty—of countless alumni.

In 1924 Taylor helped inaugurate the WPI Alumni Fund, which, the *Journal* later noted, would "consolidate and translate a somewhat latent Tech spirit into a financial response which carried the Alumni Fund way beyond the mere budget requirements of the Alumni Association." With the help of the Alumni Fund Board, which he organized, the fund was frequently ranked among the top college funds in the nation in terms of alumni participation.

Taylor's skill and innovation brought him national recognition and led to his election as president of the American Alumni Council, an association of college alumni secretaries that exists today as the Council for the Advancement and Support of Education (CASE). But it was through his literary and editorial talents that he may have had his greatest impact. His timely editorials in the *Journal* and his rousing letters to alumni were universally enjoyed and admired.

Recognizing the role of favorable publicity in building the stature of an educational institution, Taylor expanded the Institute's relatively modest public relations activities. He hired Stephen D. Donahue '29, a reporter for Worcester's *The Evening Gazette*, to run the first college news bureau in Worcester. Donahue, who later became an assistant copy editor at the *Gazette*, worked at WPI part time for 45 years.



Taylor's most notable accomplishment as a writer was *Seventy Years of The Worcester Polytechnic Institute*, the college's first history. With the encouragement and editorial advice of William L. Ames, a member of the

Class of 1882 and a former professor of drawing at WPI, Taylor spent seven years researching and writing this comprehensive and eloquent survey of the people and events of WPI's early years. Ames also paid to have the book printed.

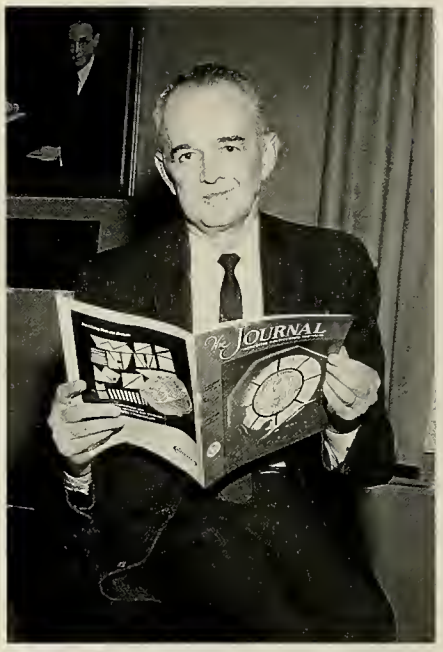
By 1946 Taylor, fighting a losing battle with tuberculosis, was often weak and in pain; he edited his final issue of the *Journal* from his bed shortly before his death. Though illness slowed his usually hectic pace, he devoted as much energy as he could to passing on his extensive knowledge of WPI lore and his considerable insight into managing the association to those who would succeed him.

One of those pupils was Donald E. Smith '41, who became WPI's second full-time secretary in April 1946. After receiving his degree from WPI, Smith spent a brief time working for civil engineering consulting firms before joining the WPI faculty in 1942. The "Smith years" in the Alumni Office, he says, picked up where the "Taylor years" left off. "Herb had made himself, the association, the Alumni Fund and the *Journal* something akin to institutions. My task was to build further on what he had created, and to go beyond, if possible."

Smith says he remembers his seven years in office as a time of significant expansion for the association. For example, he says, annual contributions to the Alumni Fund nearly doubled, from $31,000 to $58,000.

"Considering the fact that the Alumni Office budget [then supported entirely by alumni contributions] was only $15,000 at the time, we were very pleased to see the growth in alumni contributions," he says. In his second year as secretary, Smith logged more than 13,500 miles as he traveled around the country visiting alumni chapters to explain the goals of the association, which no doubt contributed to the success of the fund.

"The 13,500 miles doesn't seem like much today," he says, "but those were automobile or train miles. And the train miles were of the variety where I arrived in a city one morning, visited alumni, attended an alumni meeting in the evening, and then caught a train to the next city. Oh, to be young again!"



MARVIN RICHMOND

Warren Zepp '42 held the post of alumni secretary from 1953 to 1971.

Smith ran a one-man shop during his time in the secretary's chair. His responsibilities included editing the *WPI Journal*, and in his seven-plus years on the job he produced 43 issues and more than a million words. In 1949 the magazine was named one of the 10 best alumni periodicals in the U.S. by the American Alumni Council.

Smith spearheaded the production of the college's first postwar alumni directory—"the hard way," he says, "word by word and pre-computer." While compiling information for the directory, Smith sent each alumnus a postcard with a label showing how their entry would appear in the publication. "That, together with the information we had already collected, served in a rather massive way to bring our central records up to speed after the disruptions of war," Smith says.

During these years the Institute—and the association—became much more involved in student recruiting. "The Techni-Forum [a program in which high school principals, science instructors and guidance counselors visited the campus] was initiated, regional prospective student screening committees were established, and the promotional movie *Bridge to the Future* was produced and distributed widely." The film, created under Smith's supervision, won wide acclaim in the early 1950s.

Smith resigned from his alumni post in 1953 to take on the responsibilities of direc-

JANET WOODCOCK

The parade of alumni at Reunion each spring is just one of many events made possible by the WPI Alumni Association.

tor of university development at Washington and Lee University in Lexington, Va. He would later become vice president of university relations and development at the University of Rochester, founder and president of a consulting firm, and vice president for development and university relations at Southern Methodist University, a post from which he retired in 1984. He now lives in Rancho Santa Fe, Calif.

After Smith's resignation, Warren B. Zepp '42, who had been a member of WPI's mechanical engineering faculty for 11 years and had recently accepted the additional duties of acting superintendent of the Washburn Shops, was named to serve as alumni secretary on an interim basis.

Zepp, whose previous work for the association included service as secretary-treasurer of the Worcester County alumni chapter, was named permanent secretary a year later. In his first message to alumni in the *Journal* he noted that though he would miss the rewards of teaching full time, his new duties shared a "common purpose" with his former role: "the promotion of the ideals of independent education so inherent at Worcester Polytechnic Institute."

In that message Zepp listed for alumni two critical ways they could help advance the mission of the Institute: helping in the recruiting and screening of applicants for admission to WPI and contributing to the Alumni Fund. Throughout his term as alumni secretary, which concluded in 1971, Zepp was impressed by how well alumni participated in both activities, he said in an interview shortly before his death last spring.

"The things I remember most about my years as alumni secretary," he said, "are how alumni willingly pitched in to help find new students for their alma mater and how they helped make a WPI education possible for some of these new students by contributing money for scholarships."

In 1971 Zepp became a special advisor to the vice president for university relations. Replacing him as alumni secretary was Steve Hebert, who had been assistant secretary since 1969. After earning his degree in civil engineering from WPI, Hebert worked as a teacher and coach in the public schools in Springfield, Vt., where he had grown up.

Hebert's appointment coincided with the beginning of a major period of change for the Alumni Association. From its earliest days the association had been an independent entity, set apart from the operating structure of the college. In the late 1960s the association and the Institute began discussions aimed at bridging that gap and linking the organization more closely to the interests and management of the college.

"A number of alumni leaders were of the opinion that the association would be more efficient and effective if its daily operations were part of the college operating structure," notes Hebert, who in 1986 took on the responsibilities of secretary of the WPI corporation in addition to his duties as alumni secretary and treasurer. Among those who planned and helped carry out the reorganization that ultimately resulted from those discussions were Robert E. Higgs '40, who served as president of the Alumni Association from 1969 to 1971, Irving James Donahue Jr. '44, association president from 1971 to 1973, the late George W. Hazzard, WPI president from 1969 to 1978, and the late Thomas J. Denney, vice president for university relations from 1971 to 1983.

Higgs summarized one of the primary motivations for the reorganization—the changing character of the WPI graduate—in a 1969 message in the *Journal*. "The WPI graduate of today is far more concerned and involved than his predecessor," he wrote. "We believe that this increased participation and acceptance of responsibility is the result of a two-way interaction. The role of our Alumni Association is now one of continuous activity and responsibility. It is the kind

JANET WOODCOCK

From their offices in Higgins House, headquarters of the Alumni Association, Lisa Hastings, left, and Sharon Davis direct WPI's many alumni programs.

of organization that attracts responsible people who want to make significant contributions to worthwhile causes."

While some alumni feared the association would lose too much of its autonomy by merging with the college, the majority of graduates approved the union, and on June 5, 1970, the association and the Institute joined forces. For the employees of the association, the first tangible sign of the new coalition arrived with their next round of paychecks, which came not from the association, but from the college.

"The marriage has been a happy one," says Hebert. "What little independence the association may have lost has been more than made up by a stronger association and a better-served college."

Today the association concentrates much of its efforts on providing services to its members and to helping advance the goals and missions of the Institute. The association's activities range from raising funds for student scholarships, to developing programs that help alumni and students plan and advance their careers, to organizing Reunions and Homecomings.

Says Paul W. Bayliss '60, president of the association from 1985 to 1987, "In recent years we have revised the association's long-range plan and initiated programs for the involvement of students and younger alumni, such as Career Day and the Major Selection Program."

Under the direction of Sharon C. Davis, director of alumni programs, and associate director Lisa M. Hastings, the association also organizes alumni travel programs, provides group insurance and charge card plans for alumni, publishes the alumni directory, and markets WPI memorabilia to association members. To observe its 100th anniversary, the association has built a Centennial Walkway on the Quadrangle in the center of campus. Alumni, students, faculty, staff and friends of the college may purchase inscribed bricks to be included in the walk.

Programs like the Centennial Walkway are created by the Alumni Office in collaboration with the various committees of the Alumni Association. All told, about 500 alumni serve on these committees; of these, 100 (representing individual classes and regional clubs) serve on the Alumni Council. Twenty-one alumni serve on the Executive Committee, including the officers, officers-at-large, former officers, and the chairs of Alumni Association committees.

The Alumni Fund Board, staffed by Alumni Fund director Elizabeth B. Siladi, helps manage a range of alumni fund-raising programs, including anniversary gift programs, phonothons and the President's Advisory Council. (Donors of $1,500 or more are named to the PAC; membership is granted to alumni who have graduated in the past five years for gifts of $500, and to those who graduated in the past six to 10 years for gifts of $1,000.)

In the 1970s and 1980s the Alumni Fund received several U.S. Steel Awards from CASE. These recognize the best alumni fund-raising programs in the nation. Between 1979 and 1985, the Fund won six awards for sustained excellence, a record exceeded by just one other college in the nation—Gustavas Adolphus College in Minnesota.

Last year the Alumni Fund raised $2.2 million, including corporate matching gifts, with 35 percent of alumni making contributions. "We hope to double that giving within the next five years," says Hebert. Contributions to the Alumni Fund exceeded $7.4 million (including corporate matching gifts) during the last four years of the recently concluded *Campaign for Excellence.*

Unrestricted dollars from alumni are vitally important to the operation of the college, Hebert notes. In addition, he says gifts from alumni in anniversary classes in recent years helped the college build a new information sciences building, modernize its outdoor athletic facilities, and create the new Bioprocess Laboratory, among other projects.

Keeping younger alumni involved with the association is a constant challenge, Hebert notes. Many go on to graduate school, or become involved with their careers, their families and community activities. An increasing number live far from Worcester. "One of the biggest problems with young alumni is just keeping track of them," says Hebert. "Every year we process

Below, Alumni Fund director Elizabeth Siladi poses with the 1991 Reunion gift chairs. From left, Siladi, Daniel Maguire '66, former association president George T. Abdow '53, Leonard H. White '41, G. Albert Anderson '51, and WPI President Jon C. Strauss.

NEIL NORUM

A candlelight parade capped off Traditions Day in 1991, a new program sponsored by the Student Alumni Society.

between 8,000 and 9,000 changes of address—the majority for younger alumni."

Hebert says many young alumni are discovering an especially rewarding way to get involved with their alma mater—advising student projects. Helping students complete the qualifying projects required under the WPI Plan enables young alumni to maintain their contacts with faculty members and friends. "Academic advising is the one area where we usually have more alumni volunteers than we can involve," Hebert says.

JANET WOODCOCK

Recognizing the need to get younger members involved with alumni programs as early as possible, the association launched the Student Alumni Society in the early 1970s to help students understand the aims and functions of the Alumni Association. Through the SAS, students help with fundraising phonothons and other alumni programs. This spring the society sponsored a new campus event, called Traditions Day, aimed at reviving many of WPI's student traditions.

Getting women graduates involved with the association has not been a challenge, Hebert reports, despite the fact that, since the college did not admit women until 1968, the association was oriented toward men for much of its history. As their numbers grew, female alumni became increasingly involved with the management of alumni affairs. Today they hold a disproportionate number of leadership roles in the association. Hebert says their enthusiasm and vision are extraordinary.

In the May 1947 issue of the *WPI Journal*, Donald Smith summed up the main purposes of the WPI Alumni Association. "Fostering reunions and homecomings and sponsoring district chapters are important elements of the alumni program," he noted, "but they are only the means to an end—not the end itself." According to Smith, who is president of his class and editor of its 50th Reunion yearbook, the real goal of the association is to stimulate alumni interest in WPI and then convert that interest into utility to the college.

While Steve Hebert concurs with Smith's assessment, he notes that the association also exists to serve its members. "Opening up a new career possibility to a graduate, planning a special trip for alumni enjoyment, or furnishing a scholarship to a worthy student—these are things the association can do to help individual alumni and students," he says.

"These are also things that help bring our graduates closer to each other and to their alma mater. And, when all is said and done, that is the true purpose and the greatest accomplishment of the WPI Alumni Association."

Saving Vernal Pools

Major Qualifying Project by David J. Kircheis '92 and Lisa Taikitsadaporn '92.

Advisors: Nabil I. Hachem, assistant professor of computer science, Jeanne W. Ross, assistant professor of management, and Stanley M. Selkow, professor of computer science.

Sponsor: Massachusetts Audubon Society

Encroaching civilization has muted the sounds of the world's swamps and reduced their animal and plant populations. The Massachusetts Audubon Society wants to ensure that the state's vernal pools, home to throngs of frogs, toads, salamanders, fairy shrimp and other creatures, are protected from further destruction.

Vernal pools are temporary ponds formed in low, swampy areas near streams and other sources of water, or in isolated depressions in wooded areas. The pools are full for at least two months in the spring and summer, but are partially or completely dried up the rest of the year.

Taikitsadaporn and Kircheis worked with Betsy Colburn, an aquatic ecologist with Massachusetts Audubon, to design a user-friendly database management system—a collection of programs that will enable the society to record, process and report new and existing information concerning the locations of vernal pools. The database will also contain information about the physical and chemical characteristics of the pools, the periods when they are flooded, and the species that inhabit them.

From left, Mass. Audubon's Colburn and WPI's Taikitsadaporn and Kircheis.

The new system will help the society identify pools that qualify for certification by the Massachusetts Natural Heritage and Endangered Species Program, administered by the state's Division of Fisheries and Wildlife.

"With this database we will also look at how well vernal pools are being protected under Massachusetts' Wetlands Protection Act and other laws, and join the data with our own studies to improve the understanding of these seasonal wetlands," says Colburn.

Lifting the Veil on a Chemical Process

Major Qualifying Project by Francis A. Christiano '91, Gary T. DelGrego '91 and George E. Oulundsen '91.

Advisor: William R. Moser, professor of chemical engineering.

Using a table-top, high-pressure reactor invented by Moser in 1983 and a technique called cylindrical internal reflectance, Christiano, DelGrego and Oulundsen analyzed the mechanics of a large commercial chemical process called the halcon propylene oxide process.

Each year in the U.S. the process is used to convert propylene to about 5 billion pounds of propylene oxide, used, in turn, to make chemicals used in the manufacture of urethane foams and polyester resins.

Like many chemical processes, the halcon propylene oxide process employs a catalyst, a chemical that alters the rate at which the reaction occurs but is itself unchanged by the reaction. In their work the students looked at the mechanics of this chemical process, in other words the step-by-step manner in which the reaction proceeds from its starting point to a finished product.

They discovered a catalytic intermediate, a previously unidentified step in the reaction that is responsible for the success of the process. By helping reveal the mechanics of the process, the students' work may enable other researchers to find ways to improve its efficiency.

From left, DelGrego, Christiano (seated) and Oulundsen.

Despite its small size, the reactor used for the study is capable of analyzing a variety of commercial chemical reactions under controlled conditions of temperature and pressure. The reactor uses a beam of infrared light to measure the concentrations of reactants, products and catalytic intermediates in a high-pressure zone at the center of the device, notes Moser, who has been studying the mechanics of homogeneous metal-catalyzed reactions for many years.

"The type of research we do reflects the close collaboration between academics and industry," says Moser. "We've received funding or equipment from a number of major corporations and from the National Science Foundation, and we expect that our technology will be patented and, ultimately, licensed."

The project was voted the best MQP in chemical engineering completed at the Institute last year and was awarded third place at the 1991 New England Regional Undergraduate Chemical Engineering Research Competition.

Moser presented the students' results and related research at the Pittsburgh Analytical Institute Conference in March and will submit the study to an international catalysis journal.

—Bonnie Gelbwasser

Tales From the Gulf

Bringing the Scudbuster to Israel

The order came from President Bush on the heels of the first Scud missile attack on Israel: "I want Patriot missile batteries moved to Israel and operational within 72 hours."

Army Col. David Heebner '67, commander of the Patriot task force, had already moved one battalion to Saudi Arabia from Germany. When the immediate deployment order arrived, he obeyed, but not to the letter—his troops and cooperating Israeli military forces had Patriot batteries ready for use in Israel in less than 27 hours.

Says an Israeli army colonel who had returned to Israel following Patriot training at Fort Bliss in the U.S., "I think we achieved a world record for getting a Patriot battery operational. The first night the battery was up, an incoming missile was downed. Absolutely amazing!"

Heebner has nothing but praise for the Patriot missile. "When I arrived in Tel Aviv in January and saw the massive destruction visited upon residential areas by the Scud terrorist missile, I was grateful for the power of the Patriot as a countermeasure."

Before the Patriot batteries were deployed to Israel, civilians left work at 3 p.m. and returned at 8 a.m., gas masks always at the ready. Cities became ghost towns after hours. When the highly accurate Patriots arrived, Israeri citizens gained confidence and began to lead more normal lives.

COURTESY ISRAELI DEFENSE FORCES

Heebner, second from right, accepts a gift of a special bible from representatives of the Israeli Defense Forces while U.S. ambassador to Israel William Brown, center, looks on.

"Whenever people realized who we were, they would call out, 'We love you,' as we drove by," Heebner says. "They also invited us into their homes, fed us, and treated us like royalty. At war's end they took us on tours to historic, recreational and cultural sites."

Heebner says he and his troops were so close to the civilians that whenever they knocked out a Scud they felt as if they were protecting their own families. "The closeness carried over into everyday life," he says. "We had 700 American soldiers in Israel for three months, and never had to report any disciplinary incidents."

With the success of the Patriots, the Scud attacks slowed. "The Patriot almost became a victim of its own success, however," Heebner reports. "We had to keep a large supply of missiles on hand, and sometimes we ran dangerously low. Raytheon came to the rescue by turning them out around the clock. Someday I hope to drop by the plant and thank them personally for what they did for all of us."

Cooperation between the American and the Israeli military was exceptionally close, says Heebner, considering the fact that Operation Desert Storm was the first time foreign troops had ever joined forces with Israelis on their home ground. The Israelis, he discovered, are highly motivated and "quick studies" when it comes to learning new military techniques. They became expert at downing Scuds with a minimum of missiles. "Patriots cost $800,000 each," he reports. "Israeli accuracy saved lives and money."

Heebner says the Israelis were moved by the dedication of their American colleagues. Said one Israeli officer, "I was prepared to serve 24 hours a day for my country. I was completely surprised, however, to see that the Americans also willingly worked around the clock, just as if they were defending their own country."

Currently executive officer to the second-highest-ranking Army general at the

EDITOR'S NOTE: *Many WPI alumni served overseas in a variety of capacities during the Gulf War. We featured some of their stories in the Class Notes section of the Spring 1991* WPI Wire *and will continue to highlight the veterans of Operation Desert Storm, as we learn about them, in future issues of that publication. On these pages we present the stories of three alumni who saw the war from quite different perspectives.*

Heebner visits one of the Patriot batteries that helped knock out Iraqi Scud missiles aimed at Israel.

Pentagon, Heebner says his experience in Israel was unforgettable. "We were there to save lives," he says. "We were welcomed with open arms and we carried out a successful mission."

In July Heebner returned to a hero's welcome in Gardner, Mass., where his sisters had arranged a surprise party for him at the VFW post. More than 75 friends and relatives were in attendance as he received a U.S. Senate proclamation praising his meritorious service in the Gulf.

"That celebration was the icing on the cake," Heebner says. "I'm a Vietnam veteran and this welcome was much different from the earlier one."

Night Raids Over Iraq

Twenty minutes after the start of the Gulf War, Lt. Joseph Mitchell '87 was dropping laser-guided bombs on a chemical weapons storage bunker in western Iraq, not far from the Israeli border.

"I was never more scared in my life," he says. "When I made it back safely, along with everybody else in my outfit, I never felt better. The enemy had 210 anti-aircraft artillery pieces, plus 14 surface-to-air missile sites and fighters all against us. We'd been told to expect 15 percent losses."

Mitchell, a first lieutenant in the U.S. Air Force, served as a weapons system officer on an F-111 tactical fighter bomber during the war. He later received the Distinguished Flying Cross for hitting a weapons storage facility in Kuwait. "We flew at night through cloudy weather and intense defenses around Kuwait City," he says. "Another fighter bomber had been unable to target the facility, but we hit it."

Mitchell, who received his degree in electrical engineering from WPI in 1987, began active duty at Mather AFB in California. He later went to Cannon AFB in New Mexico, then joined the 492nd Tactical Fighter Squadron based at the Royal Air Force base at Lakenheath, England. Last November though, he was 20 miles from Mecca in Saudi Arabia, preparing for war.

He says his group trained at night, flying at low levels and practicing weapons delivery. "We learned to use the radio less," he says, "so the other side would have a harder time finding us."

As a weapons system officer on the F- 111, Mitchell was responsible for flying and navigation, getting the aircraft into position, and providing laser guidance to the target. "We used only smart bombs, which are highly precise," he says. Later in the conflict he took part in bombing Iraqi tanks. By war's end he had flown 30 missions.

Once, after hitting a target, Mitchell had to depart from his flight plan when a Patriot missile locked onto his plane, confusing it for an enemy aircraft. "I had to call an AWACS (a special radar-equipped command plane) on the radio to stop it," he reports.

Some of the video recordings Mitchell made from his plane look like the images of bombing runs that amazed millions of television viewers during the war. "But war is no video game," he cautions. "In war someone is shooting at you and if you mess up, you die. You don't get a chance to put in another quarter."

Mitchell, who attended WPI on an ROTC scholarship, has always wanted to be a pilot. "I got bit by the flying bug as an undergraduate when I saw some F-111s flying during an ROTC training course," he recalls. After finishing at the top of his class in

CAROLYN HINE

After his return home in May, Mitchell attended a Memorial Day observance in his hometown of Watertown, Mass.

leadership training, he was allowed to switch from a technical category to a flying category.

Slated to be promoted to captain in October, Mitchell may finally get his wish. He has been assigned to the newer F-15E fighter aircraft, since the F-111s are being taken out of England, and he will have the option of training to become a pilot.

Feeding the Troops

While serving as a chemical officer at Fort Bragg, N.C., in September 1990, U.S. Army Lt. Lisa Partridge '88 was ordered to Saudi Arabia where, as a battalion personnel and administration officer, she would soon find herself accountable for the whereabouts of 1,300 soldiers.

"It was my job to know where the troops were, whether or not they were getting their mail, and whether they were engaged in any legal actions," she reports. "Little did I know they were breaking me in easy," she says. "Later my battalion was given the responsibility of feeding thousands of troops, including the entire 18th Airborne Corps."

According to Partridge, one unit worked on obtaining perishable food wherever it was available. Most staples came from the U.S., and the Saudi government donated fresh fruit and sodas. In "dry" Saudi Arabia, the troops dubbed one staple, the chocolate bar, "the desert bar."

NEIL NORUM

Partridge, photographed at WPI after her return to the U.S. in April, says she was surprised by the welcome she received.

Besides searching out food supplies, Partridge contracted for laundry services. In both areas, she dealt with the Saudi military. "The Saudi men treated the American female military just like regular soldiers," she says. "But in social situations, there was a definite change of attitude."

Partridge, who was an Army ROTC student at WPI, was stationed at Dammam, just outside of Dhahran, a favored target of Iraqi Scud missiles. "We were very grateful for the Patriot missiles," she says. "We saw dozens of Patriots taking out Scuds."

Partridge poses at Logistics Base Charlie, located on the border between Saudi Arabia and Iraq.

She was later stationed at Log Base Charlie, located near a P.O.W. camp on the Saudi-Iraqi border. "It was there we were visited by Secretary of the Army Michael P. Stone," she says.

Partridge spent over seven months in the Gulf. "We suspected from the beginning that sooner or later war would break out," she says. "The soldiers maintained high morale and were ready to fight. When Saddam didn't carry through on his threats, what followed was a textbook war worked out to the last detail by General Schwarzkopf."

She says she was astonished at the casual attitude of nearby inhabitants during the war. "Right in the middle of hostilities we could see caravans of Bedouin tribesmen with camels and goats crossing the battlefields," she notes.

As for the weather, it was either hot and dry, or rainy and muddy. "In spite of the torrential downpours," she says, "the next day the ground would be dry as a bone."

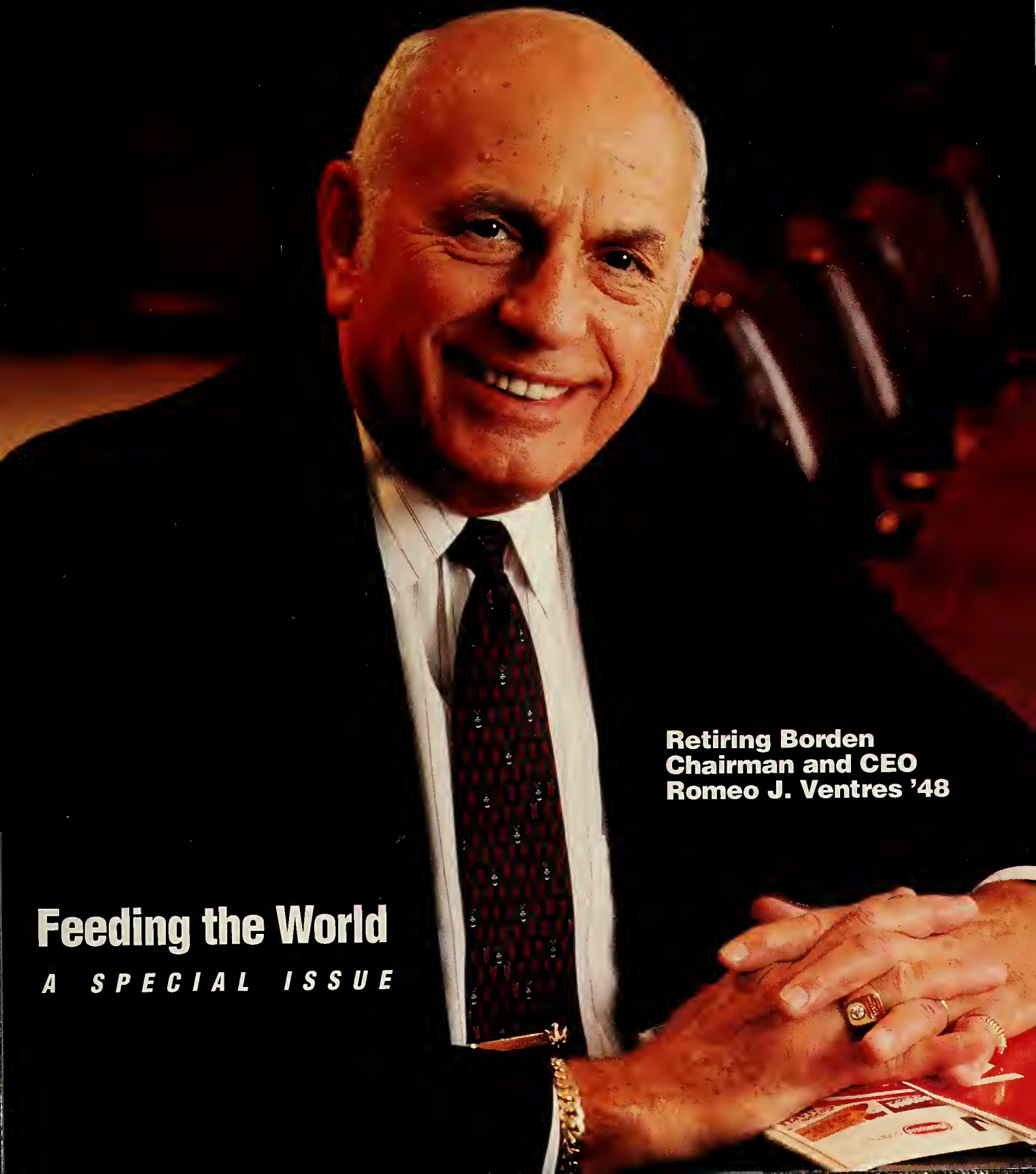
Partridge returned to the U.S. on April 18. "Our plane stopped over in Bangor, Maine," she says. "We knew by the flood of mail we'd received in the Gulf that the American people supported us. But we had no idea how much until we saw the huge cheering crowds at the Bangor airport. I'm still flabbergasted!"

—Ruth Trask

WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

FALL 1991



Retiring Borden Chairman and CEO Romeo J. Ventres '48

Feeding the World

A SPECIAL ISSUE

Front Cover: Romeo J. Ventres at Borden Inc. headquarters in New York City. Story on page 4. Photo by Doris Barnes. **This page:** A carpet of fall leaves settles in the doorway of Salisbury Laboratories. Photo by Robert S. Arnold. **Back Cover:** The annual cranberry harvest at the Manomet, Mass., bog owned by William F. Shields '64. Story on page 14. Photo by Janet Woodcock.

WPI Journal

VOLUME XCIV NO. 4 FALL 1991

A Special Issue: Feeding the World

Few activities are as fundamental as eating, and few things give us greater pleasure than food well grown, processed and prepared. Here's a look at the jobs of several WPI alumni who make their living in this most fundamental of all businesses.

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Before the Main Course, A Few Appetizers

When you think about the many fields in which WPI's 20,000 living alumni make their livings, more than likely, the food business won't be high on your list. But the fact is, WPI graduates are into food in a big way. Starting with Romeo J. Ventres '48, retiring chairman and CEO of Borden Inc., one of the world's largest food producers, the list includes executives with food processors and marketers, plant managers, food store owners, restaurateurs, farmers and many, many others.

We selected a small sample of these alumni to illustrate the broad range of food-related jobs WPI graduates hold, and put together this special issue of the *WPI Journal*. We hope you enjoy this look at an industry that touches each of us in a fundamental way.

Pasta and Veal Naples Style (Pasta e Cotolette alla Napolitana)

Provided by Romeo Ventres. **Makes 4 servings.**

1/2 (1-lb) pkg. linguine, cooked and drained
2 eggs
1/2 tsp garlic salt
2 cups plain dry bread crumbs
2 Tbs olive oil
Grated Parmesan cheese or shredded mozzarella cheese
2 Tbs water
8 veal cutlets (about 1 lb), pounded thin
1/2 cup butter or margarine
1 (26 oz) jar Classico Di Napoli (tomato and basil) or Di Parma (four cheese) pasta sauce

In medium bowl, beat eggs, water and garlic salt. Dip veal in crumbs, then in egg mixture, then again in crumbs. In large skillet, over medium heat, melt butter with oil; brown veal on both sides. In medium saucepan, heat pasta sauce. Arrange veal on linguine; top with pasta sauce. Garnish with cheese. Refrigerate leftovers.

Chicken Roman Style (Pollo alla Romana)

Provided by Romeo Ventres. **Makes 4 to 6 servings.**

1 (2 1/2 to 3-lb) broiler-fryer chicken, cut up
3 ounces prosciutto or cooked ham, thinly sliced and cut into strips
1 (26 oz) jar Classico Di Roma Arrabbiata (Spicy Red Pepper) or Di Salerno (Sweet Peppers and Onions) pasta sauce
1/4 cup dry white wine
1/4 cup olive oil
1/2 (1-lb) pkg. fettuccini, cooked and drained

In large skillet, brown chicken in oil. Remove chicken; pour off oil. In skillet, over medium-high heat, cook prosciutto or ham until lightly browned. Reduce heat; stir in pasta sauce and wine. Return chicken to skillet; cover and simmer 20 minutes or until chicken is tender. Serve chicken and sauce over hot cooked fettuccini. Refrigerate leftovers.

Veal Scaloppine Ala Marsala

Provided by George Abdow '53, chairman, Abdow's Big Boy Restaurants, Springfield, Mass.

1 1/2 pounds sliced veal
4 Tbs sweet butter
2 large garlic cloves, crushed
3/4 cup marsala or sherry
1/2 Tbs finely chopped parsley leaves
Salt and black pepper
4 Tbs olive oil
1 tsp rosemary, crumbled
Linguine or egg noodles, cooked & drained.
All-purpose flour
5 slices prosciutto, diced
1 can (16 oz) small French peas

Pound veal to about 1/4" thickness. Sprinkle both sides of veal with salt and pepper, to taste. Dip veal in flour and shake off the excess. Heat butter and oil in a large skillet. Add the veal slices and prosciutto and sauté for three minutes; turn and cook for three minutes more. Add garlic and rosemary while cooking. Add wine

(Continued)

for three more minutes. Warm contents of can of peas in a sauce pan (do not boil), then, without draining, add to the skillet. Add parsley and cook for 5 minutes more. Serve over linguine or egg noodles.

**For variety, omit the peas and continue as follows: When the veal is browned on both sides, transfer to a platter. Pour off most of the fat from the skillet, leaving just a thin film on the bottom. Add the wine and 1/4 cup chicken or beef stock. Boil briskly over high heat for about 2 minutes. Scrape the bottom and sides of the pan. Return the veal to the pan, cover, and simmer over low heat about 12 to 15 minutes, basting the veal with the pan juices. Transfer the veal to a heated platter and add about 1/4 cup of stock to the remaining sauce in the skillet. Boil briskly, scraping the bottom and sides of the pan. When the sauce has a syrupy glaze, taste for seasoning, and if necessary, add more salt, pepper and granulated garlic. Remove the pan from the heat and stir in a pat of butter; pour the sauce over the veal.

Cranberry Pecan Pie

Provided by William F. Shields '64
Red House Bogs, Manomet, Mass.

1 cup fresh cranberries, chopped	1 unbaked 9-inch pastry shell
3 eggs	1 cup dark corn syrup
2/3 cup sugar	3 Tbs butter or margarine, melted
Dash of salt	3/4 cup pecan halves

Preheat oven to 350° F. Spread cranberries in pastry shell. Beat eggs just to blend. Stir in corn syrup, sugar, butter or margarine, and salt. Pour mixture over cranberries. Top with pecan halves and bake for 45 to 50 minutes, or until knife inserted in the center comes out clean.

A man hath no better thing
under the sun, than to eat,
and to drink,
and to be merry.

—Ecclesiastes

A warning: As you read these pages, don't be surprised if you're overtaken by an urge to run to the kitchen and whip up something to eat. Anticipating that, we asked a few of our subjects to provide a favorite recipe or two. We invite you to clip and save these recipes and, perhaps, try them out during the upcoming holiday season. Bon appétit!

—Michael Dorsey

Ice Cream Shop Pie

Makes 8 servings.

Provided by Robert Cassanelli '62
Kraft General Foods Inc., Tarrytown, N.Y.

1 1/2 cups cold half-and-half or milk
1 pkg. (4-serving size) Jell-O Instant Pudding and Pie Filling
3 1/2 cups (8 oz) Cool Whip Whipped Topping, thawed
1 pkg. chocolate, graham cracker or vanilla crumb crust
Ice Cream Shop ingredients (see below)

Pour half-and-half or milk into large bowl. Add pudding mix (see below for flavor) and beat with wire whisk until well blended (1 to 2 minutes). Let stand five minutes or until slightly thickened. Fold whipped topping and Ice Cream Shop ingredients into pudding mixture. Spoon into pie crust (see below). Freeze pie until firm (about 6

(Continued)

hours or overnight). Remove from freezer. Let stand at room temperature about 10 minutes before serving to soften. Store any leftover pie in freezer.

Ice Cream Shop Ingredients:

Rocky Road Pie: Use any chocolate flavor pudding mix and chocolate crumb crust. Fold in 1/2 cup each, Baker's Semi-Sweet Real Chocolate Chips, Kraft Miniature Marshmallows and chopped nuts into whipped topping. Serve with chocolate sauce, if desired.

Toffee Bar Crunch: Use French vanilla or vanilla flavor pudding mix and graham cracker crumb crust, spreading 1/3 cup butterscotch sauce onto bottom of crust before filling. Fold 1 cup chopped chocolate-covered English toffee bars (about 6 bars) into whipped topping. Garnish with additional chopped toffee bars, if desired.

(Continued)

Strawberry Banana Split Pie: Use French vanilla or vanilla flavor pudding mix, reducing half-and-half to 3/4 cup and adding 3/4 cup pureed Birds Eye Quick Thaw Strawberries with the half-and-half. Use vanilla crumb crust and line bottom with banana slices. Garnish with whipped topping, maraschino cherries and chopped nuts. Serve with remaining strawberries, pureed, if desired.

Chocolate Cookie Pie: Use French vanilla or vanilla flavor pudding mix and chocolate crumb crust. Fold 1 cup chopped chocolate sandwich cookies into whipped topping.

Nut Cracker Pie: Use butter pecan flavor pudding mix and graham cracker crumb crust. Fold 1 cup chopped mixed nuts into whipped topping.

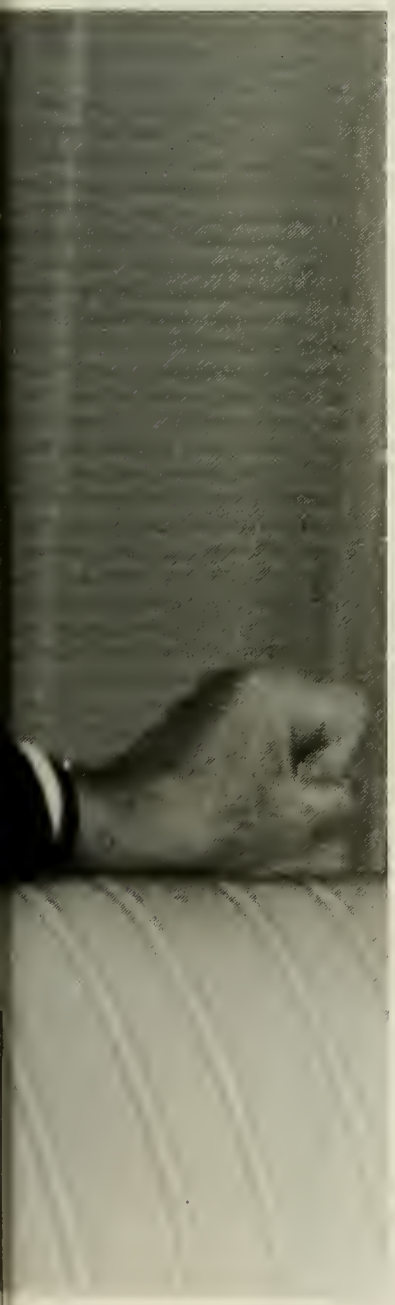
Peppermint Stick Pie: Use French vanilla or vanilla flavor pudding mix and chocolate crumb crust. Fold 1/2 cup crushed hard peppermint candies, 1/2 cup Baker's Semi-Sweet Real Chocolate Chips and 2 tsps peppermint extract into whipped topping.

A Man

DORIS BARNES

By Michael Dorsey

OF THE PEOPLE



Over the course of his more than four-decade career, Romeo J. Ventres '48 has honed a personal approach to managing people that has helped them—and the companies they work for—succeed. In recent years, as chairman and CEO of Borden Inc., he has used that philosophy to rebuild and renew one of the world's largest food companies.

It's a rainy September afternoon and Romeo J. Ventres '48 is having his picture taken in Borden Inc.'s spacious boardroom, 39 floors above the noisy Manhattan streetscape. Ventres smiles and then blinks just as the strobes flash.

As the photographer angles for another shot, Ventres stops her. "I'm going to share a secret I learned from another photographer," he says, speaking with that delicate balance of patience and enthusiasm that marks all good teachers. "Before you take the picture, say, 'Blink.' That way, I'll blink *before* you press the shutter. Try it. It works."

To a casual observer, the exchange is just friendly banter between two professionals. But in fact, the moment says much about the philosophy that has guided Ventres, Borden's retiring chairman and CEO, for more than four decades. For while other corporate heads might feel more comfortable speaking the arcane language of sales, earnings and stockholders' equity, Ventres' passion is people.

"I can honestly say that in my 43 years of working I have spent a third of my time training people," he says. "That's a number I've calculated carefully. You see, I learned early on in life—by luck—that results are a consequence of the growth and development of people."

By putting people first, and finding ways to unleash the talent and creativity of the employees who have served under him, Ventres has consistently helped the companies he has worked for grow and prosper. Six years ago, when he was named president of Borden, a world leader in the processing and packaging of food that placed 64th on the most recent *Fortune* 500 list of U.S. companies, he used the same approach to supervise the corporation's 44,000 employees. In the process he helped rebuild Borden, leaving it leaner, more focused and better prepared to face the challenges of the decade ahead. "I've been a manager since September 1950," he says, "and I've been guided since then by the same basic principles. You see, I have a lot of faith in people, and I haven't been let down many times."

The fifth of six children of Italian immigrants Christy and Marzia Ventres, Romeo Ventres was born in Boston in 1924 and raised an hour to the west in Worcester. After graduating from the city's North High School, he entered WPI in 1942, but left to serve for two years as an aviation electronic technician's mate in the U.S. Navy. He received his bachelor's degree in chemical engineering from the Institute in 1948 with distinction, earning membership in Tau Beta Pi, the national engineering honor society.

Motivated by the advice of one of his professors, who'd often tell his students about industries that used the types of unit operations taught at WPI, Ventres set his mind on finding a job in the oil industry. "I also wanted to go into foreign work," he says, "because I'd read so many times how working in a foreign country could open up a lot of career opportunities."

Before he graduated, Ventres was interviewed by several oil companies with overseas operations. "But nobody wanted me," he says. "That was a great disappointment, particularly since I was first in my class in chemical engineering. I ended up taking a job with Atlantic Refining Co. (now Atlantic Richfield) in Philadelphia."

Ventres says that first job dispelled one myth he'd held about industry. "We'd learned all these theoretical things in school, like heat transfer calculations," he says, "but in industry we didn't use any of them—it was all rules of thumb and tables of numbers. I realize now how important it was to understand the theory behind all those tables, but it was disappointing, nonetheless."

For a time Ventres, who'd rejected an offer of a graduate assistantship from WPI because he was anxious to start his career, considered going back to school. But then, after two years at Atlantic Refining, he returned from a vacation to find that he'd been promoted to group leader. "That was something of a shock," he says. "Here I was feeling disillusioned, and they promoted me."

At that time, Ventres says, Atlantic was sending all its new first-line supervisors to a five-week course where they were taught the basics of managing people. "That course was a major turning point in my life, because it opened up the field of management to me. I fell in love with managing people."

In his first supervisory position, Ventres oversaw the work of three other engineers in Atlantic's motor oil division. "I enjoyed it so much I started doing an awful lot of training—and it started to work," he says. "After two years with these engineers, they got promoted and moved on. My boss thought I'd had some luck with these new recruits, so every year he'd send me the new crop."

As a manager, Ventres says his watchwords were training, motivation and development. "I found that by giving these fellows a feeling of confidence, of self-worth, I could help them achieve things. I could see how that motivated them, and in fact, performance was steadily up for the whole group."

In time, Ventres says he came to realize that he had been rejected for foreign assignments right out of school because most oil companies reserved such positions for experienced engineers. So, after putting in more than seven years with Atlantic Refining, he responded to a newspaper ad placed by the Iraqi government, which was looking for engineers to help get new refineries started.

"I ended up moving to Iraq with my family and working there for two years, the first year as a senior process engineer and the second as assistant department head," Ventres says. "I supervised more than 30 engineers—a mixture of Americans and Iraqis. I used the same ideas of training, development, encouragement and goal setting that I'd

COURTESY BORDEN INC.

The Borden family of products includes a host of popular food and nonfood items.

COURTESY BORDEN INC.

This hyperplant in Berwick, Pa., makes snacks for Borden.

had success with at Atlantic Refining, and they worked as well with the Arabs as with the Americans. I had a great two years there, a really enjoyable period of achievement and 'people growing'.

"They wanted me to stay another three years, but conditions there were not good for family life. I didn't want to expose my wife and four children, one of whom was born there, to more of that life, so we moved back to the U.S. in 1957 and decided to live in the Worcester area to be near our parents."

Through an employment agency, Ventres found a job as assistant chief engineer at Borden's Leominster, Mass., plant, where about 30 employees were churning out polyvinyl chloride (PVC) and polyvinyl acetate co-polymers. Within a year, Ventres was named chief engineer; he became operations manager in 1961 and, five years later, general manager of the thermoplastics division, which by then employed about 350 people.

"Though the business was different, I kept doing things the same way," Ventres says. "And once again, I found that working with people—encouraging them, building their confidence, and setting goals—got results."

In 1968 Ventres' success earned him a promotion to vice president of Borden's chemical division, which put him in charge of all of the company's PVC operations. Four years later, when he was named a division group vice president, he also assumed responsibility for Borden's petrochemical operations in Louisiana. "That was a highly integrated plant where we used natural gas, ethylene, chlorine and other raw materials to make vinyl chloride, methanol, ammonia and urea—all basic petrochemicals," Ventres says. "We were the state's second largest user of natural gas, after the electric utilities, consuming 60 billion cubic feet a year."

In 1971 Borden moved its administrative headquarters to Columbus, Ohio, leaving just a small group of senior corporate officers in New York. Ventres was asked to relocate from Leominster to Ohio, but not wanting to uproot his seven children, all of whom were still in school, he commuted from Leominster to Columbus for two years. "After two years I finally realized I wasn't going to get anywhere unless I moved," he says, "so I resigned and took a job with a small chemical company in Philadelphia."

Ventres wore many hats as executive vice president of this specialty chemicals company, which had annual sales of about $1 million. The company did well until the recession hit in 1976, he says. It was sold in 1978. The following year Ventres returned to Borden as group vice president in charge of the company's adhesives, energy resources and Canadian operations. Four years later he would be named president of the division, a member of the Office of the Chairman and a corporate executive vice president.

In 1985 Ventres would find himself in the No. 2 spot at Borden, as the company called him back to New York to become president and chief operating officer. He was named CEO about a year later, with the retirement of Eugene J. Sullivan, who had also been his predecessor in the president's chair; the following February Ventres assumed the additional responsibilities of chairman.

I am a goal setter," Ventres says, summing up the management style he has followed throughout his career. Goals, Ventres says, have a special power to inspire and motivate people. Setting goals, he says, gives those you manage confidence, because you're telling them you believe they can achieve them. Properly set, goals push employees to do more than they thought themselves capable of. And, goals become yardsticks against which employees can measure their own performance. In the parlance of the chemical engineer, goals are catalysts that spur employees to work faster, achieve more, and raise the company to new levels of achievement.

"A goal is a lot more than it sounds like," Ventres says. "It communicates so many things—it's probably one of the most important tools in management today, and most people don't realize it. Setting goals gives you the opportunity to work with people. You become a partner; you can help them and coach them. And it builds teams."

First as president and then as chairman and CEO, Ventres has used ambitious goals to turn the 44,000 employees of Borden into a team with a unity of purpose. "When I became corporate president, I had four division presidents reporting to me. When I gave those presidents goals, and they were all working toward common objectives of improving corporate net income performance, earnings per share and return on shareholders' equity performance, they became a team."

Before Ventres could give those presidents meaningful goals, though, he had to choose a strategic direction for Borden. For Ventres, a chemical engineer who had spent 37 years in the chemical business, that would prove to be no easy task, as he now found himself in charge of a company with the bulk of its business in food products.

"I became president with the prospect that in about a year and a half I'd be CEO," he says. "I realized I had to quickly figure out what to do. So I spent three or four months studying the needs of the company and what resources we had to work with. After study I saw the opportunity to focus the company's business more closely."

Borden Inc. was founded in 1857 by Gail Borden to capitalize on his invention of condensed milk, the first effective way to preserve milk. Over the years the company became a major player in the dairy business and slowly diversified into other food and commodity products. Then came the 1960s and 1970s, when many major corporations caught diversification fever. During those two decades, Borden acquired dozens of companies making everything from disposable diapers to cosmetics to women's clothing.

By the start of the 1980s the company was approaching $5 billion in sales, but its stock was selling at below book value, making the corporation an attractive target for a takeover. Faced with this threat, along with rising natural gas prices that threatened its petrochemical businesses,

and with double-digit interest rates that were slashing profits, Eugene Sullivan started a restructuring program.

Over the next few years, the company sold off businesses accounting for 20 percent of its sales, including commodity businesses like sugar and fertilizer, and other companies outside its areas of expertise. When Ventres took over the reins, the time had come to assess the remaining businesses and map out a strategy to grow them.

Ventres identified six strategic growth areas: dairy, pasta, snacks, "niche grocery," nonfood consumer products, and films and adhesives products. The company began with a sizable regional dairy business, the Wise snack business in the East, and several regional pasta brands, including Creamette. Its nonfood consumer businesses included the Elmer's family of consumer glues and Wall-Tex wallcoverings, and its films and adhesives businesses included PVC packaging film and forest-products adhesives, in which it held the leading position. The niche grocery category began with 19 food brands, all of which had big positions in relatively small market niches. These included Eagle Brand sweetened condensed milk, ReaLemon, Cracker Jack and Snow's clam products.

However, with the exception of dairy and forest-products adhesives, the company's businesses lacked both the leading market positions required to compete in the 1980s and the mass needed to achieve the economies of large-scale production, thus enabling Borden to become a low-cost producer. Ventres set out to rectify this with a plan that called for quick growth in the six strategic areas.

In 1986 Borden launched a two-pronged attack of strategic divestiture and acquisition. First, the company began selling off companies and divisions that fell outside of the six strategic growth areas. At the same time it began searching for ways to add mass and market reach to those same six areas.

Ventres' plan included four methods for building mass: introducing new products, enlarging the geographic range for each of the product areas, building market share in those geographic areas, and acquiring new companies. Of these, acquisitions promised to generate the fastest rate of growth, so Borden began an aggressive plan to acquire strong regional companies that fit into the six growth areas.

To date, Borden has bought 90 companies and businesses at a cost of $1.9 billion. At the same time, it has divested itself of 31 other operations, recovering $1.2 billion. The strategy produced immediate results. From 1985 to 1990, Borden's sales increased by 62 percent, to $7.6 billion; net income rose 88 percent to $364 million; earnings per share gained 97 percent to $2.46. The current stock price of about $33 per share is nearly double the price at the end of 1985—$17.25. Today the company's 115 brands represent over 2 cents of every retail dollar spent on food in U.S. supermarkets.

The acquisitions brought Borden the mass it was after. But they also brought with them scores of additional production plants, lifting Borden to 265 facilities around the world, far more than were needed. The next step in Ventres' plan called for consolidating production as much as possible into large plants and closing down as many smaller and less efficient plants as possible. Part of the savings could then be put into more advertising and marketing to build visibility and market share for the company's growing empire of national and regional brands.

"In September 1989 we announced a major program called reconfiguration," Ventres says. "We said we were going to close or sell 65 of the 265 plants—including 20 dairy plants—build 11 big plants called hyperplants, and withdraw from certain dairy markets that were not profitable enough. Over two years we were going to have to spend about $700 million—the largest capital investment program in Borden's history. We took a $571 million pretax charge against our profits to pay for all of the costs associated with closing plants, including severance pay and job-hunting assistance, environmental cleanup, and equipment write-off.

"We also said we would complete this program, which would normally take five to seven years, in just two and a half years. The program is on schedule and will be completed in early 1992. In the meantime, the recession and a major price-cutting war in the salty snack business have combined to reduce our profitability."

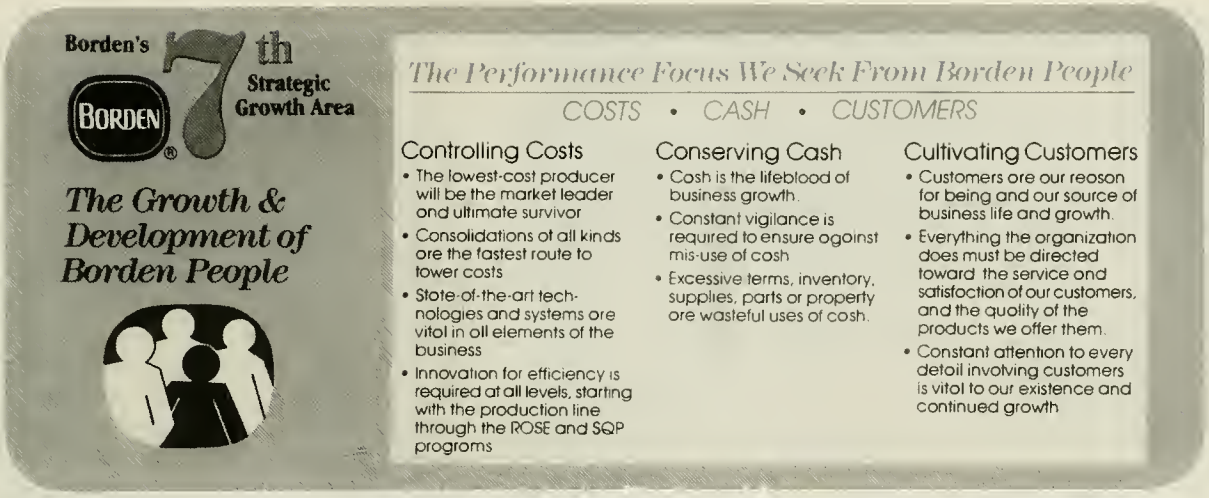
In an announcement to financial analysts on Sept. 4, 1991, Borden said its 1991 earnings per share would probably run between $2.35 and $2.40, compared to $2.46 in 1990. "We expect to resume our profit growth in 1992," Ventres says.

When profit growth resumes, he says, it will be powered by the dramatic growth in business size, market strength and production efficiency achieved since 1986. For example, Borden is now the No. 1 producer of pasta in the world and the world's top maker of wall coverings. It is the leading U.S. dairy and holds the No. 2 slot in North America in the snack business. The company holds the No. 1 or No. 2 position in 27 niche grocery categories and is a world leader in films and adhesives.

Borden's success in pasta has been particularly dramatic; in fact, pasta has replaced dairy as the company's flagship business.

COURTESY BORDEN, INC.

Some of Borden's many pasta brands, including Creamette, center.



To satisfy security analysts, Ventres established a seventh strategic growth area focused on the development of Borden people. He had cards like this one distributed to all of Borden's 44,000 employees.

After acquiring 28 regional pasta brands, including Prince (Northeast and North Central), Globe A-1 (California), R•F (Midwest) and Ronco (Midsouth and Southeast), Borden was able to consolidate its pasta production into 15 North American plants, including six hyperplants. A hyperplant in St. Louis—the largest in North America—makes five times the pasta produced in the plant it replaced with just 30 percent more employees.

The acquisitions also gave Borden the undisputed lead in one of the fastest growing categories of food in the U.S. "If you were going to design a perfect grocery product, you couldn't do better than pasta," Ventres says. "It's versatile, inexpensive and convenient with a perfect nutritional profile for our times: low in fat and sodium, no cholesterol, and high in complex carbohydrates. And, you receive oral gratification when you eat it, because of all the shapes it comes in."

Americans are eating more and more of this perfect product every year. In fact, per capita pasta consumption in the U.S. has jumped from 12 pounds in 1980 to 19 pounds today (by contrast, Italians eat more than 55 pounds per person). In addition to giving Borden a highly profitable product, the regional pasta company acquisitions have enabled it to do what no other American food producer has accomplished—develop a truly national pasta brand.

"Several companies tried to take their pasta brands national," Ventres says. "They failed because they couldn't fight the regional brands, which could afford to defend their own turf. By acquiring more regional brands across the country, we were able to put Creamette into the national distribution system we had built. Now, not only is Creamette the only national brand in all 50 states, it also has the leading single brand share—more than 12 percent."

Not long after Ventres outlined Borden's six strategic growth areas, security analysts began asking when he would name a seventh area. "I said, 'Look, there's still great growth potential in these six areas. We'll look for a seventh when we no longer see growth in them.' They kept after me, so finally I said, 'I'll show you the seventh growth area. It's the growth and development of Borden people.' "

The "Seventh Growth Area" now refers to a comprehensive series of employee recognition and development programs that have taken Ventres' belief in empowering people and made it a companywide imperative. "At Borden we've got people spread over 30 countries in manufacturing and marketing," Ventres says. "If we're going to unleash the power of these people, we have to share with them fully our vision of the future. I can't touch all of them individually, but I can reach them through our communications program. I believe communications are vital. An organization is really a set of human linkages; communications is the oil that lubricates those linkages."

The Borden communications program includes the *Management Quarterly* for supervisors worldwide, and the *Borden Eagle* newspaper, which seeks to share strategies, problems and business realities with company employees everywhere. However, Ventres has taken Borden far beyond the usual communications efforts into a pioneering program that involves employees at every level.

In 1988, under his direction, Borden launched a program called SQP, which is directed toward the continuous improvement of safety, quality and performance in Borden production plants. The program enlists employees in improving a plant's record in each area, and then shares with them the gains in productivity with awards of up to $1,000 apiece.

Each plant establishes its own specific goals in safety, quality and performance, with safety coming first (in fact, no awards are made unless safety and quality standards are met). In 1990, 10,000 people—a quarter of all Borden employees worldwide—shared the SQP awards for improvement. The company also improved an already excellent safety record with an additional 40 percent reduction in recordable accidents in SQP plants over two years.

"SQP was built upon the principle that people want to be better, and if they are given an opportunity to surpass their prior year's record in performance, they will grow as a result—as people and employees," Ventres says.

Recently, Ventres received approval from the board of directors to launch a new program to further reward exemplary employees. Annually over the next five years, employees at plants with the best performance toward their SQP goals will each receive 100 Borden stock options. The options give the employees the right to buy 100 shares of

COURTESY BORDEN INC.

Nur Hier, one of Borden's retail bakeries in Germany.

Borden stock at a fixed price for up to 10 years. Should Borden's stock continue to increase in value at the rate it has over the past decade, the options would generate a profit of more than $21,000, before taxes.

"In many companies today, the talent that exists in employees is bottled up, largely due to the historically adversarial relationship that has existed between management and labor," Ventres says. "These programs are designed to unleash that pent-up talent and creativity and put it to work for Borden."

With Borden's reconfiguration nearly complete and the foundation for the company's future growth well established, Ventres says the company can now look ahead to new opportunities. For example, meeting the demands of an increasingly health-conscious nation with products that are low in fat, cholesterol and salt is an area Ventres says is particularly exciting. In addition, he says, the company will be looking beyond the U.S. borders for much of its future growth.

Already, Borden derives 31 percent of its overall sales from international markets (up from 18 percent in 1987), and sales from those foreign markets continue to grow faster than sales in the U.S. In recent years Borden has placed particular emphasis on acquiring companies in Europe and building a strong Pan-European marketing and distribution network in advance of the consolidation of the European Community at the end of 1992.

Currently, Gallina Blanca, a 27-year-old joint venture in Spain, is that country's leading maker of dry soups and bouillon. In Germany, where the population eschews salty snacks like potato chips and pretzels for sweets, Borden owns Wilhelm Weber, one of the nation's largest commercial bakers, and three leading regional chains of retail "corner" bakeries.

The company also has successful operations in Canada (where Borden is the leading seller of pasta and pasta sauce), the Pacific Rim (where the company recently ended a long-term joint venture in Japan and established its own operations) and Latin America (where dairy and pasta operations are market leaders). With the collapse of communism in Eastern Europe, Borden quickly expanded its German bakeries into East Germany and purchased a state-owned bakery there. It has also opened four bakeries in Hungary and is studying business opportunities in Czechoslovakia and Poland.

"Those are the opportunities," Ventres says. "The challenges are cost, cost and cost. With the consolidations that occurred in manufacturing in the 1980s and the ongoing consolidations among food distributors and supermarkets, the need for cost containment is unbelievable.

"We jumped on the opportunity to streamline the operations we assembled during our acquisition program. Now the competition is so fierce, especially with the recession, that had we not done so we would not be in a position to reduce our costs further." Ventres notes that several other major food producers, facing the same competitive pressures, are just now beginning the type of reconfiguration and consolidation programs that Borden set in motion two years ago.

Ventres says Borden is looking to research and new technology to bring additional cost savings in the years ahead. In particular, he says, the company will be applying an engineering perspective to food processing. "When you look at the food business, you see that it's really based on chemical processes, yet it has always been more marketing oriented. We're beginning to put process engineers in all of our plants and beginning basic research programs in food technology."

For example, he says, the company is currently investing heavily in basic research into pasta—its molecular structure and weight distribution, the chemical changes that occur when it is formed and cooked, and the technology with which it is extruded and dried. "We see this work resulting in reduced costs and new differentiated products."

Much of the responsibility for this new phase of Borden's business will fall on Ventres' successor, Anthony S. D'Amato, who, like Ventres, is a chemical engineering graduate. On Nov. 1, Ventres yielded the CEO's chair to D'Amato. He will retire as chairman on March 1, 1992.

After his retirement, Ventres will serve as a consultant to Borden and continue as a director and chairman of the board's executive committee. He says he plans to stay busy as a member of the boards of directors of Banc One Corporation, Marsh & McLennan Companies Inc. and Schering-Plough Corporation, and as a trustee of St. Clare's Hospital and Health Center in New York.

When time permits, he says he hopes to travel with his wife, Norma, spend more time with his children and grandchildren, play tennis, and indulge his love of fishing ("I haven't fished much since I've had this job," he says). He'll also serve as cheap labor for his two sons, who have started their own company to build high performance engines. One son is an Ohio State mechanical engineering graduate and the other a current WPI student also majoring in mechanical engineering. "I've always kept busy," he says, "but I haven't had time to do any of my own projects, so I have a lot of catching up to do. But I'll be keeping my eye on Borden. It's an exciting company, and I have to say I've had an exciting six years helping to transform it."

Putting Food On the Table

A number of WPI alumni make their living directly from the soil, helping produce the nation's bounty of fruit, vegetables, grain and livestock. Here are the stories of three of these food growers.

Howard Atkins '34: *Farming is in his Blood*

SUSAN SCHACHT, DAILY HAMPSHIRE GAZETTE

The next time you reach for a crisp, sweet-tart McIntosh apple, thank the family of Howard Atkins '34. His grandfather, George Atkins, introduced the McIntosh to Western Massachusetts in the late 19th century, and today the variety accounts for more than two-thirds of all apples grown in New England. More than a century later, the Atkins family continues to produce the McIntosh in prodigious numbers.

"We grow about 100,000 bushels a year," reports Howard Atkins, who at 79 still runs Atkins Farms in Amherst, Mass., part time with his sons, Dale and Dan. "My wife, Ruth, and I are semiretired at our home in Sugar Hill, N.H.," he says, "but I spend a lot of time at our farms in Massachusetts. I love the land."

Loving the land has been a four-generation affair for the Atkins family. Grandfather George, a door-to-door tree salesman, founded the original farm in 1887. Since then it has expanded from a 100-acre apple orchard to a spread of more than 250 acres of apples, peaches and pears cultivated in Amherst and Belchertown. The business includes a cider mill, a large retail store that sells

produce, baked goods and deli items, and a 20-acre, pick-your-own fruit operation.

George Atkins' first commercial produce sales were to a string of 20 small grocers in Holyoke, Mass. William Atkins, who inherited the farm from his father, replaced horse-drawn wagons with trucks for deliveries and shifted sales to the wholesale markets in New York City.

William's son Howard left home as a young man to study at WPI. After receiving his bachelor's degree in mechanical engineering, he worked briefly in a shop making typewriters. But the call of the land was too great, and within two years he returned to the family business.

In 1956, four years after purchasing the farm from his father, Howard Atkins bought the business's first cold storage system, which keeps apples in an airtight environment at under 36 degrees Fahrenheit. Another of his innovations was a retail store, Atkins Farm Fruit Bowl, which opened on West Street in Amherst in 1962.

"The first fruit stand was a big success," says Atkins. "Each year sales increased until we outgrew the building. In 1972 we had to triple it in size. Later we added a greenhouse and baking facilities. The retail outlet now handles 20 percent of our produce, with the remainder going to supermarket wholesalers."

Among the many types of produce the store sells are pumpkins. Most popular are sugar pumpkins for pies and the larger, coarser-fleshed Halloween pumpkins, which are used mainly for decoration. The farm also sells gourds, which, Atkins says with a smile, were used by pioneer women to darn stockings.

In 1970 Atkins was elected to the board of directors of Agway Inc., the farmers' cooperative, in a district that includes Connecticut, Massachusetts and Rhode Island. "My greatest honor," he says. He was also elected to the board of Curtice-Burns, a food processing cooperative. The two organizations do more than $900 million worth of business annually. Locally, he served Amherst on the town's Finance Committee and Board of Selectmen in the 1950s and 1960s.

During the past few years, Atkins says, it has been increasingly difficult for the orchard business to be profitable in the Northeastern market, due to "the high cost of doing business imposed by the state of Massachusetts." The family has sold several parcels of land, but is continuing with its apple and pumpkin harvesting and the retail store.

In spite of the change in business climate, Howard is not yet talking of complete retirement. "Farming is in my blood," he says. ❧

George Meyer '46: *Farming in Spite of the Government*

GEORGE MEYER III

From left, George Meyer Jr.; Conrad Baehr, a Taiwan missionary; George's wife, Ruth; son Donald and his wife, Julie; Eve Meyer, wife of son George III; George and Eve's son Michael; son Walter; George and Eve's daughter Mary Beth; son Robert with his wife, Phyllis.

The U.S. government is difficult to farm with, and yet it is impossible to farm without," says George Meyer Jr. '46, who owns and operates Meyerlea Farms, an expansive, 725-acre grain and dairy operation in Russellville, Ky. "Currently, four of my sons and I have 135 acres of alfalfa, 230 acres of corn, and 185 acres of wheat and soybeans under cultivation. We also have 115 milking cows and more than 100 dry cows, calves and heifers. As we operate our business, we know from experience that the government, with its constantly fluctuating and conflicting policies, can undercut everything we try to accomplish."

Meyer says one of the most frustrating aspects of farming is that farm prices are influenced by world events, for which the U.S. may or may not be responsible, and are set by the availability of goods in international markets.

"The government appears to be unable to police the Commodities Exchange and keep it honest," he comments. "It doesn't set standards that will keep multinational grain companies from making deductions from the price they pay us for grain and then adding inert matter to the grain before resale. This gives the U.S. a poor image in world trade."

Another Meyer criticism is that Congress can't seem to pass annual farm bills before planting time, with the result that farmers can't plan for good rotations. In many cases, he says, they have already invested large sums in crops that have to be destroyed. And, he says, the use of grain for political purposes, such as President Jimmy Carter's withholding grain from Russia, is counterproductive.

"We've lost 20 percent of our wheat export markets in the last 10 years because of a government incentive to limit production," he says. This is in contrast to European programs that subsidize grain prices, encouraging more production."

According to Meyer, government milk-marketing orders use the Minnesota-Wisconsin cheese price in computing the minimum price farmers are paid for fluid milk. "Last year, when the Minnesota-Wisconsin cheese price hit a new high, producers benefited and sold their milk for $1.37 per gallon, with consumers—as expected—paying higher prices. This year prices are still up for the consumer, but producers are receiving only $1.08 per gallon." Processors and retailers, he says, are pocketing the difference.

Meyer thinks the biggest government

interference yet may come when the international GATT (General Agreement on Tariffs and Trade) Treaty is ratified. "President Bush is willing to delete the section that has to do with import quotas in order to appease Europeans, whose heavily subsidized, excess dairy products and grain will then be dumped on the world market, severely depressing U.S. farm prices," he says.

On the other hand, Meyer applauds government action in Kentucky aimed at eradicating Bang's Disease (brucellosis), an infectious disease that causes fever in cattle and other animals, including man. "We reaffirm the court rulings controlling animal rights activists," he says. "We also approve of the EPA's checking our farm's manure disposal lagoon, and feel strongly that the government should have a national policy for solid waste disposal."

Despite his difficulties with government decision making, Meyer says he is addicted to farming, although he came about it via a roundabout route. He studied at WPI and then went on to earn his bachelor's degree at Lehigh University. For 19 years he was a mining engineer with the New Jersey Zinc Co.; for 10 of those years he taught vocational agriculture at Sussex County Vocational Technical School.

"My wife, Ruth, and I brought up our seven children in New Jersey," he says. "When we decided to move to Kentucky, we sold the New Jersey farm we'd owned since 1950 at the first farmland auction ever held in the state. It was a beautiful property next to a pond and adjacent to a monastery and a golf course."

The family decided to move to Kentucky because taxes are lower there and because there are fewer state restrictions on farming. They also needed room to expand. In 1980 they bought their new farm at auction, "mainly because my wife liked it at first sight," says Meyer.

Once settled in Kentucky, Meyer made a number of changes at the farm. For example, he added a second, modern Harvestore, an oxygen-limiting silo for high-moisture corn. This structure, in conjunction with an automated feeding system for the cows, lowered feed costs. The system did so well that Meyerlea Farms received the Agricultural Proficiency Award from the University of Kentucky.

Meyer's registered holstein herd, which is milked in an automated milking parlor, produces an average of 17,500 pounds of milk and 700 pounds of butterfat per day.

Although his farm doesn't have a computer, Meyer has the use of computer resources provided by the Dairy Herd Improvement Association, which records his herd's feeding, breeding and milking history and gives each cow an official milk record. The University of Kentucky keeps track of the entire operation for income tax purposes.

All of the feed used on his farm is tested for nutrients, Meyer says. The cows are fed chopped alfalfa, corn silage and high-moisture corn grown on the farm, and cottonseed, soybean meal and minerals, which are purchased. A total ration is calculated by computer using the amounts of forages available until the next harvest.

Meyer limits the use of pesticides and sprays in his farming operation, except for the chemicals he uses on an especially pesky kind of weed. "Johnson grass," he says, "grows to about 6 feet tall. We had to spend $5,900 on spraying recently to get rid of acres of the stuff."

In spite of Johnson grass, intermittent droughts and the latest decrees from Washington, Meyer shows no sign of slowing down. He is a voracious reader of agricultural publications and is totally committed to keeping up with the latest developments in his profession. He says he is proud that his sons are following in his footsteps. The sign at the entrance to his property reads, Meyerlea Farms—George Meyer *Family.* ❧

Joseph Weber '57: *Learning the Ropes in the Apple Business*

Apple producer Joseph Weber '57 didn't inherit a family farm. Instead, he turned his vacation property in Hendersonville, N.C., into a paying apple orchard.

"We purchased the farm while my wife, Joyce, and I were with Pratt & Whitney in West Palm Beach, Fla.," says Weber, who holds bachelor's and master's degrees in mechanical engineering from WPI. "She was a buyer at P&W and I was assistant materials project engineer. We still maintain our residence in Florida, but live in North Carolina during the apple season."

Weber took early retirement from P&W, in part to look after his 15-acre orchard. His operation is small, and he depends on other assets to make a living, but he says he enjoys what he does.

"We sell apples to fruit stands and food processors," he says. "Seneca Foods uses our produce to make apple juice. We harvest several thousand bushels annually—mostly golden and red delicious varieties, plus Romes and Stayman winesaps. We also have a pick-your-own section, which is popular. This area of western North Carolina is primarily agricultural and is noted for its apples."

Weber says there are many rewards in apple farming, such as being able to run one's own business. "There are pressures, too, but they are different from the ones we had at P&W," he says. "We do most of the work ourselves." One ongoing problem is that they must spray their trees on a rigorous schedule from March until August to protect their crop and remain competitive.

Joseph and Joyce Weber in their North Carolina orchard.

According to Weber, there is an abundance of government regulations decreeing what chemicals may or may not be used in pesticide sprays. "Because of these regulations, available fungicides are now less effective," he explains. "This means we have to spray more often, which may be damaging the environment even further."

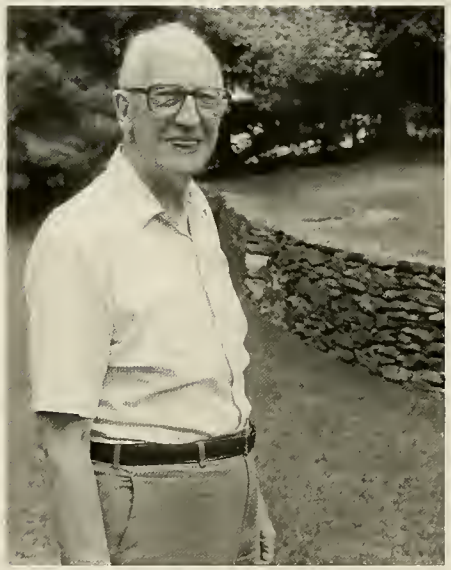
Surprisingly, he says, it is the buying public that indirectly demands apple spraying. "Customers won't buy fruit that looks a little off-color or has surface blemishes," he reports, "even though the fruit is perfectly good inside. In a sense, the public is its own worst enemy.

"I've been an apple farmer for only four years," Weber says, "and I'm still learning the ropes, but it's obvious to me that less spraying will benefit all: the farmer, the consumer and the environment." ❧

—Ruth Trask

WPI Alumni Lead Berry Fulfilling Lives

Growing and processing cranberries is a satisfying and profitable business for the members and employees of Ocean Spray.



ROGER N. PERRY JR. '45

Theron Cole's family has been in the cranberry industry for generations.

A tiny fruit named for a bird represents big business to the WPI alumni who are grower/owners or employees of Ocean Spray, a Massachusetts-based cooperative. The wild American cranberry, *vaccinium macrocarpon*, was originally called a "craneberry" because its stem and hanging blossom resemble the head and neck of a crane.

Ocean Spray was the brand name on the first can of prepared cranberry sauce marketed in the early 1900s. Now known as Ocean Spray Cranberries Inc. (see related story), the company offers blended juices, cranberry sauce and fresh cranberries for use in cooking and baking.

Although he currently owns only two acres of bog, Theron M. (Ted) Cole '35 of Holden, Mass., can trace his roots to the earliest bog owners. "My family has been involved in the cranberry business since the fruit was first grown commercially," says Cole, a mechanical engineering graduate who retired in 1990 as vice president, engineering, research and development, at Parker Metal Corp. in Worcester.

In 1895 Ted Cole's grandfather, the first Theron M. Cole, converted a shoe-shipping-box factory located on property the family had owned for nearly 250 years in Carver, Mass., into a cooper shop for cranberry barrels. When barrels were replaced by smaller boxes, Ted's father, Frank H. Cole, began making them instead. The factory closed in the mid-1950s following a fire.

"I keep my property as a sentimental reminder of my heritage," Cole says. "Larry Harju, a prominent Carver-area cranberry grower, works it for a share of the income. My brother Larry and his family are still active in the business. They own and operate four bogs in North Carver, and Larry has a well-deserved reputation as a historian of the industry. Cranberry growing is hard but satisfying work, and the product is becoming more popular all the time."

Compared to Ted Cole, almost anyone would be a newcomer to the cranberry business, but William F. Shields '64, who recently harvested his 11th crop, is a knowledgeable and dedicated owner/farmer who looks right at home waist-deep in a sea of red berries. What makes an electrical engineer turned airline pilot spend his vacations and most of his spare time for six months each year slogging through bogs?

Shields, who joined the Air Force after graduation and became a fighter pilot, flew for Eastern Airlines for 16 years before joining Trump Shuttle Inc. in 1989. "In the

late '70s, my wife and I were living in a three-story townhouse near Boston's Louisburg Square," he says. "I was flying A10s for the National Guard, but I figured they didn't need any more 40-year-old fighter pilots. Elaine had left her job at Gillette and was finishing her M.B.A. at Suffolk University.

"We started looking for a business to get into and ended up trading our building on Beacon Hill for 53 acres in Manomet. The farm came with a house and an eight-acre cranberry bog that had been out of production for a year. We weren't trained in agriculture, so we went to the library and took out books, and we invited people over to teach us about raising cranberries."

A member of the Ocean Spray co-op, Shields harvested about 150,000 pounds of the thumbnail-sized fruit this year from his bogs, known as Red House Bogs, which also include two acres of leased property. The farm, like those of so many of his predecessors, is a family affair. "Elaine takes care of the financial end of the business. I have one part-time employee and I hire three others to help out with the harvest," he says. "I'm a small grower. On my days off I do whatever I can—I get out there and I get my hands dirty, and if it's picking time Elaine will be out there with me. Our daughters, ages 7 and 8, are too young to do heavy work, but help out by screening the dry-picked berries.

"The business is seasonal—that's what I like about it," says Shields. "The harvest can start anytime after Labor Day and run to the beginning of November. I do both wet and dry picking. Dry picking is easier on the berries and more cost effective, but to do it you need fair weather—you can't afford to tie up people and equipment waiting for the bogs to dry out, so many people have gone to wet picking. But Ocean Spray grower/members

JANET WOODCOCK

Wet-picked cranberries ready for shipment to Ocean Spray.

are committed to put out a quality product, so we don't sell wet-picked fruit as fresh fruit. The product lacks the staying power of the dry-picked berries because it's been hit with a device that knocks it off the vine."

With the harvest complete for this year, Shields says he'll soon flood the bogs to protect them during the winter. After they freeze, a layer of sand will be added, which will act as a mulch—"a magic potion"—that covers everything and rejuvenates the bog. The flattened vines send up new vertical growth to survive—that becomes the basis for the next crop. The water will be drained in March.

"Farming's a funny business," Shields says. "Tech-educated people think like engineers—you have to go out and get the job done, 'Bang!, Bang!, Bang!' When you own a farm you quickly find out that jobs you expect to take half an hour can take a day, so I work a half a day during the growing season in whatever form that takes—from going to the hardware store to get a part for a machine, to getting out to help pick the berries."

As Ocean Spray growers, the couple must sell their entire crop to the co-op. "The only other thing we can do with our cranberries is keep some for our personal use or give them away." In addition to the stock value, the company provides its grower/owners with the latest research and development information, disease-control strategies and an integrated pest management (IPM) program, "which means growers do not apply any pesticides or chemicals unless they have to," says Shields.

Most of the world's cranberries are grown by Ocean Spray co-op members, notes Shields. "In New England, because we have some farmers who are not members of the co-op, the percentage of berries produced and handled by Ocean Spray is actually lower here than it is in other areas of North America. Still, we have a major impact on the Massachusetts economy. Besides having their headquarters and processing plant in Middleboro, Mass., Ocean Spray contributes immensely to Cape Cod and the surrounding area. There's a whole industry in the area of people who make their living servicing the cranberry industry—making and maintaining the equipment and working the bogs."

Shields says the trick to making a decent living on a cranberry bog is limiting your debt service. "A good cranberry bog produces 200 barrels (20,000 pounds) an acre. We're getting roughly 55 cents a pound—$55 a barrel—so if you can gross between $10,000 and $11,000 an acre and you don't have a lot of debt service, you can do very well."

JANET WOODCOCK

William Shields works his 8-acre Red House Bogs part-time during the growing season.

It hasn't always been that way. "The industry has evolved," Shields says. "One hundred years ago farmers were getting $10 a barrel or 10 cents a pound; 20 years ago they were still getting 10 cents a pound. People were literally giving their bogs away. You couldn't make any money. That's when Ocean Spray's president decided it had to have a new product, and it went into the cranberry juice business. That's what *made* cranberries."

James M. Asaro '74 has a different view of the cranberry industry. Asaro recently accepted a position as filtering, pressing and quality control manager at National Fruit Product Co. in Winchester, Va., but for the past four years he worked at Ocean Spray's Sulphur Springs, Texas, plant, which manufactures bottled juice and drinks and 250 mL "paper bottles" under the Ocean Spray name. The plant also co-packs bottled juices

for Tree Top and Sunsweet. In fiscal 1990 the facility's three paper bottle lines had an output of more than 1.4 million cases of finished product.

"I started as second shift bottle line supervisor," he says. "After a little over a year in that position I moved to blending operations, where I supervised the juices as they were blended and filtered, and readied the bottle lines for filling," he says. "During the past two years I was the aseptic production supervisor. I was responsible for managing 10 people who work 12 different pieces of machinery to annually produce 890,000 cases of cranberry and cranberry-blended juices in 'brik paks' or paper bottles."

The blending operation mixes cranberry juice with other fruit concentrates, water and sugar, filters it through a polisher, and then delivers it to a large holding tank that feeds either the aseptic processors or a pasteurizer. Asaro's responsibilities began at the processor, which heats the juice quickly to 220 degrees Fahrenheit and holds it at that temperature for about one minute. The sterilized product is cooled to between 60 and 70 degrees before being delivered to a filling machine.

"The filling machine," Asaro says, "forms a tube, sterilizes the packing material, and seals the tube around another metal tube containing the juice product, which is then released. What you end up with is sterilized juice in a sterile package. The container is then mechanically sealed and formed into the familiar brick shape."

Bottling supervisor James Asaro.

Asaro says his challenges were to get the production crew to produce as efficiently as possible and to stay aware of any problems with the material or the machinery. He's been quite successful—in 1990 his team set an all-time corporate efficiency record—100.7 percent.

Asaro got into the bottling industry by accident. Hoping to become a pilot, he joined the U.S. Navy in 1974 after receiving his bachelor's degree in civil engineering from WPI. He left the Navy six and a half years later with his wings as a Naval aviator. With the crisis in Iran and the rising price of gas, the airlines began laying off pilots, and Asaro gave up his dream. He worked for Pepsi-Cola in New York, Coca-Cola in Corpus Christi, and Quaker Oats in Dallas before joining Ocean Spray.

Ocean Spray pioneered the introduction of the brik pak about 10 years ago, but has seen sales of aseptic packaging steadily decrease in recent years, Asaro says. "We're down about 350,000 cases from last year. These operations are expensive, the machines require more maintenance than bottling machinery, and there's been some resistance from individuals concerned with the brik pak's recyclability."

The packaging machinery maker has defended the packaging as environmentally safe, but Asaro says he thinks that while the product will remain on supermarket shelves, it will ultimately be replaced by a larger, easier to handle gable-top package.

Like Ted Cole and Bill Shields, Jim Asaro emphasizes Ocean Spray's high standards. "We produce a premium product. It's all natural, with no artificial coloring or other additives," he says. "Quality is taken seriously by everybody—the attitude here is if the product's not good you lose customers. That's the bottom line and everyone respects it."

—Bonnie Gelbwasser

Bogs Yield a Billion-Dollar Business

If Boston is, as the poem goes, "the home of the bean and the cod," then Southeastern Massachusetts merits recognition as the birthplace of the cranberry industry.

"The ruby of the bog" grew wild in the lowlands of Massachusetts and was a popular fruit long before the arrival of the *Mayflower*. American Indians used cranberries in cooking, to treat wounds inflicted by poisoned arrows, and to color their woven rugs and blankets. The Pilgrims are believed to have included them on the menu of the first Thanksgiving feast in 1621, and a recipe for cranberry sauce appeared in *The Compleat Cook's Guide* in 1683.

Cape Cod farmers were the first to cultivate cranberries in the early 1800s; farmers in other areas of the country soon followed. Cranberries are now grown commercially in parts of New Jersey and Wisconsin and along the Pacific coast, in Washington and Oregon.

Cranberries are grown on bogs—peat swamps that are drained, cleared, leveled, spread with sand, and planted with cuttings. The plants require acid peat soil, sand and fresh water to grow, and need a long, frost-free growing season. While it takes three to five years for a new plantation to bear a crop, the vines will bear indefinitely. The pale pink blossoms appear in June or July and the fruit is harvested from Labor Day through November.

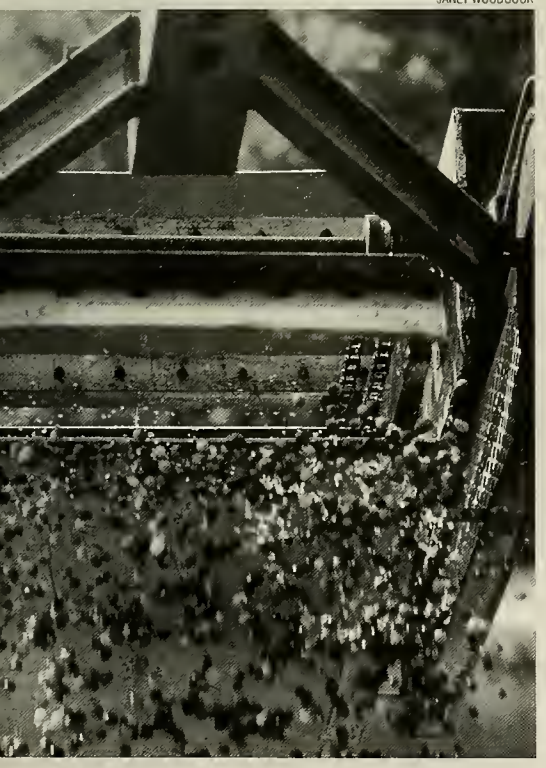
Berries can be wet or dry picked. Wet pickers flood their bogs and use an eggbeater-like machine to churn the water and dislodge the fruit, which then floats to the surface to be corralled in a process known as rafting or booming. Berries harvested from dry beds were once hand picked, but the work is now done primarily by mechanical pickers that comb the berries from the vines with their moving metal teeth.

The first can of Ocean Spray cranberry sauce was packed in Hanson, Mass., in 1912 by the Ocean Spray Preserving Co. The present Ocean Spray Cranberries Inc. was known as Cranberry Canners Inc. when it was formed in 1930. The company is a cranberry growers' cooperative formed by the merger of the Cape Cod Cranberry Co. and two other companies owned by growers interested in the production

JANET WOODCOCK

William Shields and his wife, Elaine, help harvest a bog with the so-called wet picking technique. The dislodged berries are corralled, and then raked toward a conveyor, which lifts them into a truck for transport to Ocean Spray.

JANET WOODCOCK



of quality cranberry products and in expanding the industry beyond canned cranberry sauce (then marketed exclusively under the Ocean Spray label).

In the early 1940s the cooperative expanded to include growers in Wisconsin, Washington and Oregon. In 1959 it was reorganized so that each member held shares in proportion to the average amount of berries delivered. The current name was adopted at that time to make the corporate and the brand name identifiable. During those years, the company went into the fresh fruit business, and production and distribution of Cranberry Juice Cocktail was expanded.

The company experienced significant growth beginning in the early 1970s, when Ocean Spray introduced juices blended from cranberries and other fruits. Today Cranapple, Cranicot, Crangrape, Cranorange, Cranraspberry and Cranstrawberry (all registered trademarks of Ocean Spray) account for more than 90 percent of the co-op's sales. In 1976 the company acquired the marketing co-op of Indian River Processors; since the 1980s it has been the No.1 brand in canned and bottled grapefruit juice.

Today Ocean Spray is a billion-dollar company that has ranked among the *Fortune* 500 since 1985. Growth has come from increased yields (four million barrels of cranberries were harvested in 1989), and from increased prices for cranberry products. The company currently markets about 85 percent of the total North American cranberry crop.

—Bonnie Gelbwasser

An Appetite for Success

Modern technology and a watchful eye on consumer demands keeps the cash registers ringing at Shaw's.

Keeping up with the times—or even ahead of them—is the name of the game in supermarket merchandising," says Scott W. Ramsay '68, who was recently named senior vice president of administration for Shaw's Supermarkets.

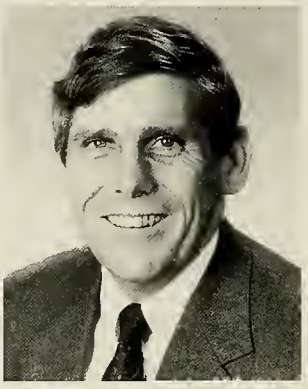
"Ten years ago, no one would have believed you could *sell* water," Ramsay says. "We didn't have aisles featuring Mexican foods and extensive lines of pasta products. We had only token displays of diet foods, and we were just getting off the ground with convenience foods."

Today, he notes, many Americans are developing a taste for international foods and vegetables. There are also a large number of health-conscious consumers who watch their waistlines and who demand a wide variety of low-calorie dinners and nutritional foods. The busy consumer leans toward the convenience of microwave meals, deli products and Shaw's own baked goods, he adds.

MICHAEL DORSEY

A Shaw's supermarket in Worcester.

To better satisfy growing demands in the marketplace, Shaw's offers a larger selection of refrigerated products and fresh produce than it did a decade ago. "Because we buy fresh produce that is off-season here, but grown literally around the world, we can stock items like fresh fruit virtually every day of the year," Ramsay says.



Scott Ramsay, senior vice president for Shaw's.

Again, with an eye on the customer, Shaw's completely updates its stores every eight years. According to Ramsay, company decorators try to retain a familiar decor, but add welcome new features such as wider, better-lighted and better-marked shopping aisles.

"We also use the latest technologies," he says. Shaw's was in the forefront of electronic scanning, which revolutionized the grocery industry in the 1980s. Most supermarket shoppers have become familiar with checkout scanning. But supermarkets also use scanners to keep track of their inventories.

"With this system we know at all times exactly what inventory we have on our shelves—by item," says Ramsay, adding that the inventory monitoring and reorder system keeps the company's buyers informed about what's in stock and automatically sends out orders to suppliers when items need to be replenished.

High-tech links between retailers and suppliers will provide even greater benefits in the 1990s, Ramsay says. "Effective electronic communication can cut days out of the inventory cycle, saving millions of dollars in inventory investments."

Ramsay says his industry is looking ahead to serving customers on a "paperless" basis at the cash register, which will enable customers to spend less time at the checkout counter. Shaw's stores currently accept cash and personal checks; in the future the firm plans to accept electronic checks, debit cards and credit cards, as well. In the case of customers who use food stamps, special magnetic-strip cards will enable the supermarket to automatically deduct the amount of food stamp-eligible purchases from the balance of recipients' accounts.

With Shaw's since 1976, Ramsay, who holds a B.S. in management from WPI, was vice president and general manager of the company's southern region before his promotion in February. He has also served as merchandising and division general manager of the central division. As the new senior vice president of administration, Ramsay is responsible for corporate accounting, finance, treasury, and risk management and loss protection for all 71 Shaw's Supermarkets.

Shaw's, headquartered in East Bridgewater, Mass., has stores in Maine, New Hampshire, Massachusetts and Rhode Island. It operates two dry goods distribution centers, a contract service for perishable products and a frozen food distribution center. A subsidiary of J. Sainsbury P.L.C. of England, the largest food retailer in the United Kingdom, Shaw's employs 16,000 workers and last year recorded sales of more than $1.7 billion.

When asked how the retail food industry is faring in these unsettled times, Ramsay replies, "The industry has changed dramatically from the times when you could simply say that no matter what the financial climate, people have to eat. Today's supermarket offers such a wide variety of items and price points that changes in consumer income can be and are reflected in our volume."

—Ruth Trask

How Sweet It Is!

Ken Wheeler enjoys life as a certified candy man.

COURTESY BUSINESS DIGEST

Priscilla and Ken Wheeler manage the Hebert's candy store in Bolton, Mass., one of the busiest in New England.

What's it like to manage one of the world's largest retail candy stores? "It's a 24-hour-a-day job," says Kenneth A. Wheeler '60, who with his wife, Priscilla, has been managing the Hebert's candy store in Bolton, Mass., since July. "Actually, it's more a way of life than a job," he says. "And we wouldn't change a minute of it!"

Ken, a high school science teacher, and Priscilla, a dental hygienist, made major career changes in 1986 when a friend, who happened to be a member of the famous candy-making Hebert family, recruited them to manage the newest branch of Hebert's Candy and Ice Cream in West Springfield, Mass.

"Neither of us had any store-managing experience," says Ken, who has a master's degree in natural science from WPI. "But after training at the Bolton store, we moved to West Springfield to run the new candy outlet. It was there we devised the schedule that we still use today."

The Wheelers' day starts at 7 a.m., when Ken comes down to supervise the custodians, who arrive at 5 a.m. to tend the buildings and grounds. "After Priscilla helps the employees balance their cash drawers, she organizes candy displays. Then I set up the self-service sundae bar. With so many ice cream and topping choices available, this is no small task."

When the store opens at 9 a.m., the Wheelers work side by side with their 20 employees serving customers and making sure that everything runs without a hitch. All through the day, candy, which is delivered twice a week, must be wrapped, packaged and labeled with the assistance of the managers. Ken oversees the cutting, weighing and packing of fudge.

Although the hours are long (he closes the store at 8 p.m.), there are many advantages to managing a Hebert's store, Ken says. "The quality of our products is exceptional. The candies sell themselves. Once customers come through the door, they are likely to remain customers for life."

High on the popularity list is Hebert's white chocolate, which Ken claims is the only pure white chocolate made anywhere. Milk chocolate is a favorite, too, but Ken says he prefers the dark chocolates. "Fred Hebert, co-owner of the company, says dark chocolate is like wine," Ken says. "It gets better with age. It develops a bouquet."

Easter is Hebert's biggest selling season. "We offer special candies at that time, such as creme eggs and bunnies," Ken says. Christmas, he adds, is busy with candy canes, chocolate Santas, and baskets featuring cuddly animals surrounded by holiday goodies. Valentine's Day and Mother's Day also attract hordes of candy-buying customers.

Hebert's makes or sells more than 400 kinds of chocolate and other candies, most of which are sold in New England. The company is expanding into the international market with a new product—a cholesterol-free chocolate bar called "Chofu." The milkless chocolate bar, which comes in four flavors, is being sold in Hebert's stores and test marketed in Canada, Europe, Asia, New Zealand and Australia.

To meet the challenge of a changing market, Hebert's is now making 100,000 chocolate bars a day for fund raising. "Many organizations need to raise extra money in these uncertain times," Ken says. "Hebert's can supply them with chocolate bars in wrappers imprinted with the name of their organization or group. The bars sell quickly. In this venture, success has been a two-way street. Everybody wins."

One of the advantages of working for Hebert's is that managers are treated like members of the owner's family, Ken says. "Priscilla and I don't own the Bolton store, but it feels like it belongs to us. We manage it pretty much on our own."

Not to be overlooked is one of the best perks of all for Hebert's managers: they're supplied with attractive living accommodations right over their stores. "I just have to walk downstairs to go to work," Ken says. "I meet wonderful people every day who buy our candy for happy occasions. And Priscilla and I never have to beg our grandchildren to come for a visit!"

—Ruth Trask

Dinner is Served!

From New England to California, WPI alumni are making diners happy in distinctive and successful restaurants and taverns.

George Abdow before his restaurant in Auburn, Mass.

George Abdow '53 and Abdow's Big Boy Restaurants

Back in 1959, when George Abdow '53 and his brother, Ronald, borrowed $10,000 from their parents to open a hamburger restaurant, they had no idea that more than three decades later they would be heading one of the largest family restaurant chains in New England.

"In our first restaurant we sold mostly fast foods, like double-decker hamburgers, sandwiches and colas," says Abdow, who is currently chairman of the board of Abdow's Big Boy Restaurants. "Today we have 23 restaurants and offer complete meals, including our specialties, fried chicken, fresh strawberry pie and Sunday brunch."

Past president of the WPI Alumni Association and a recent inductee into the WPI Athletic Hall of Fame, Abdow had no experience in the restaurant field prior to his affiliation with the Big Boy chain. After graduating from WPI as a chemical engineer, he was a shift supervisor for Du Pont at its Savannah River Plant in Aiken, S.C. "The facility is used for the manufacture and separation of radioactive materials," he says.

In the mid-1950s he served as a supervisor at the U.S. Army Chemical Center in Edgewood, Md., which was involved in the production of nerve gas. He and his brother worked briefly in their father's scrap business in Worcester, then joined the Big Boy chain by establishing their first franchised restaurant on heavily traveled Route 5 in West Springfield, Mass.

"We were lucky to get into the business on the ground floor, and to have a high-volume location that allowed for growth," he notes. "We were already established before nearby Route 91—the main highway from Connecticut to Vermont—was built."

It was also fortunate that Americans were changing their eating habits in the late 1950s. There were lots of reasons for the change, according to Abdow, who notes that mothers were working in increasing numbers, and that restaurants were getting more efficient, making the cost of dining out more affordable.

In 1963, on the heels of their success in West Springfield, the Abdows opened their first restaurant in their hometown of Worcester. Today there are four Abdow's Big Boys in or near Worcester and 19 more sprinkled throughout Massachusetts and Connecticut.

The Abdows also own several independent restaurants, including P.J. Scott's in Chicopee and Springfield, the Ivanhoe Restaurant in West Springfield, and The Griffin House in Windsor, Conn. And, they have a real estate company that buys and sells apartments and sells limited partnerships. "We own more than 1,600 apartments, mostly in the Springfield and Hartford areas," says Abdow, who received the Institute's Robert H. Goddard Award for professional achievement in 1978.

But restaurants are the heart of Abdow's business. He says he is gratified that over the past 30 years he has seen many young people recognize the career potential in the industry. "Restaurants used to be the last resort as a place to work," he says. "Now a person can do well and make a lot of money, no matter what his or her background."

George Abdow says he is getting less involved in the daily operation of the

restaurants. He and Ronald are grooming their sons, George and Stephen, to eventually take over their jobs. "When you're used to making decisions, it's difficult to stand back and watch someone else being trained to run things," he says, "but you have to yield power to the next generation if you want them to carry on the business."

And what a business it is. The Abdows have a $32 million corporation that employs more than 1,300 people, 500 of them full time. In 1959 the restaurants served 270,000 customers annually; today that total has grown to more than 7 million. The company warehouse, adjacent to corporate headquarters in Springfield, ships more than $7 million worth of groceries to its restaurants each year.

In spite of the tremendous growth of his business, George Abdow says he hasn't forgotten the early days when he and Ronald, along with their sister, Phyllis, sometimes worked 90-hour weeks. "We even took turns cooking and washing dishes," he recalls.

Robert Goodfader '60 and the Sidewalk Cafe

More than food is on the menu at the Sidewalk Cafe in Venice (Muscle Beach), Calif. Try glamour—occasionally suspect; kookiness—the 24-karat variety; and wheeling and dealing.

Just sit down and you can glimpse the glamour. If you think that's James Garner of the long-running television series *The Rockford Files* downing a burger beside you, it probably is. You may wonder why no one is unduly disturbed by a pigeon cavorting with the customers. And you may be curious about the curly-haired man with laugh lines who seems to be taking both bird and movie star in stride. He's cafe owner extraordinaire Bob Goodfader '60.

Talk about a multifaceted career. By his own estimate, Goodfader has been involved in some 42 business ventures over the years. "I'm basically a street person who finally stumbled into the right opportunity," he says. "Pure luck."

Luck? Well, hardly. With Goodfader "luck" is more than a figure of speech. At one time he was a full-fledged gambler, but one who knew the odds well enough to take home a comfortable income. Goodfader, who has a bachelor's degree in electrical engineering from WPI, fell into gambling during an Army hitch in the early 1960s. He and a buddy often hit the high-stakes poker tables in Utah, Nevada and Texas, where one could win or lose $25,000 or more a night and play with the likes of Dean Martin.

They also played with some unsavory characters who broke arms if they lost. "After I banked enough money I quit gambling professionally," he says. "I was never sure the losers would stop at merely breaking arms."

For a couple of years, he was West Coast sales manager for Sylvania Electric. During the 1960s and 1970s he was involved with numerous other businesses, including a ski and diving store, the first Los Angeles company to make psychedelic lights, and a cable television firm that became a smashing success shortly after he sold out. His most lucrative venture was Good Management Corp., which raised money for clients or helped them reorganize their businesses.

Goodfader also owned Bite of Health, a wholesale health-food catering service, and Green Bean, a natural-style restaurant, both located in West Los Angeles; Piazza, a company that buys and leases land; Ocean Walk Properties, a limited partnership that also purchases properties; and Small World Books, which owns and operates a bookstore.

"I now own a company that makes and leases machines that press pennies as mementos from places like the Grand Canyon, the Excalibur Hotel in Las Vegas, and the Hoover Dam," he says. "I also own a seafood restaurant called Breakaway."

In 1976 he took a real gamble—he bought an abandoned building in a rundown, drug-filled neighborhood and built the Sidewalk Cafe. In doing so, he was responsible, in part, for the revitalization of the whole Venice area. "Middle-class whites began coming to the cafe—mostly during the daylight hours," he says. "It's still a little risky here at night."

According to Goodfader, Venice, Calif.,

Bob Goodfader's Sidewalk Cafe is credited with helping revitalize the Venice, Calif., area.

has been offbeat ever since an entrepreneur in the early 1900s tried to turn it into another Venice, Italy, complete with canals and gondolas. He sold a few houses, then business soured. The subsequent depression and the discovery of oil virtually destroyed the town from a residential standpoint. "The oil wells were the worst problem," says Goodfader. "They stunk the place up so much nobody wanted to come here."

But, "the times they are a-changin'." L.A. is landlocked. Venice doesn't have the best beach in the world, but it's cleaning itself up and it's right next door. On a hot day you can find a million Angelinos out there, Goodfader reports.

The Sidewalk Cafe is so much a part of the beach scene, it's in great demand as a TV and movie location. Besides *The Rockford Files*, segments of *Starsky and Hutch* and the remakes of the films *Breathless* and *The Jazz Singer* were also made there. "About five to 10 movies are shot here every year," Goodfader says.

Goodfader rents out paved spaces to street vendors and film crews, netting more than $2,000 monthly for an 8-foot-by-10-foot slab. "If the crews film inside the cafe I charge $8,000 a day," he says. "They create problems."

As for the restaurant business, it gets better and better; today, crowds line up to get inside. Once there, customers share tables with strangers, European style, and choose from a menu that features omelettes, pizza, hamburgers and most American foods.

Says Goodfader, "Everyone comes to Venice from wherever they live, doing whatever it is they do that's strange, like eating fire, flexing muscles, or escaping from handcuffs. Then the tourists come down to watch the show and eat at the Sidewalk Cafe."

Steve Petroff '68 and the Shellback Tavern

Not every tavern owner can pour patrons a Bloody Mary from a bottle with his own in-house label, but Steve Petroff '68 can. In fact, Petroff, who majored in civil engineering at WPI, has been majoring in "unexpected" ever since he left the Institute.

Take, for example, his first job. "I went West to work for the Division of Highways in California, known today as Caltrans," he says. "I worked initially in their mandatory rotation system for about two years, and then had the opportunity to become involved with then state-of-the-art highway monitoring devices. My most significant project was the changeable message sign. All 36 of these are still in operation on the Los Angeles freeway system."

As fate would have it, in late 1975 California was suffering a budget crisis and Petroff's job, along with those of many other young civil engineers, fell victim to the economy. While trying to decide upon his next career move, a friend offered him a job as a temporary bartender at his bar and restaurant in Manhattan Beach. When the friend's business partner decided to sell his partnership and relocate, Petroff became half-owner of the Shellback Tavern.

"Fortunately," Petroff says, "the 'market research' I did at the Boynton while at WPI, and the social skills I learned as a member of Sigma Phi Epsilon fraternity, prepared me for this new career."

What was once a "waterfront dive" has become a beloved local establishment known for its hospitality, casual cuisine, and Bloody Marys, Petroff says. "We pride ourselves on maintaining a unique neighborhood bar atmosphere, which is becoming a rarity in metropolitan Los Angeles.

"I'm proud to say that many WPI alums have made their way west and stopped by for a visit. It's always great to renew old friendships and to make new ones."

Patrons enjoy the Shellback Tavern, Petroff says, because it has satellite television and is able to show sporting events normally unavailable on home TVs. "You'd be surprised how many Red Sox and Celtics fans there are out here. There are also plenty of Cubs and Bears fans, as my wife, Carla, a native of suburban Chicago, reminds me," he says.

Food at the Shellback reflects the casual, homey atmosphere. The tasty and hearty fare includes sandwiches, salads and daily specials at lunch, and Italian, Mexican and American dinners in the evening. On weekends omelettes and eggs Benedict highlight a bountiful champagne brunch.

Petroff describes the decor of his tavern as plain "neighborhood." "We have a 25-foot sit-down bar, several stand-up bars, and tables and booths—all of which offer unobstructed views of the Manhattan Beach pier and the beautiful Pacific," he says.

In spite of Petroff's claim that the Shellback is "just a neighborhood bar," the Miller Brewing Company obviously thinks otherwise. The company featured a photo of the tavern on a promotional poster for Miller Light beer (below). "Miller has changed the name of the tavern to 'Spike's' to honor legal limitations," Petroff says, "but practically everyone in the area knows that Spike's is us. We've gotten a lot of good publicity from the poster."

At the moment Petroff is marketing his Bloody Mary mix under the Shellback label in California and Nevada. It's so popular that even his local competitors use it in their own establishments. It is also being stocked in a growing number of markets and package stores. "We're purposely going slow in this," says Petroff, "and depend mostly on word-of-mouth advertising.

"Our goal," he says, "is to increase distribution of the Bloody Mary mix and perhaps attract the interest of a larger company." Reorders have already surpassed projections, so he may not have to wait long.

—Ruth Trask

It's Always Time to Make the Donuts

For more than three decades, quality and a commitment to freshness have been making dough for the Dunkin' Donuts chain.

Though he's never baked a muffin or a Munchkin, John E. Rogozenski Jr. '67 knows that somewhere in the world it's always "time to make the donuts." For the past 15 years he's been employed by Dunkin' Donuts, whose television commercials featuring the clock-watching baker have made that refrain part of American culture.

"Dunkin' Donuts has about 2,500 shops owned by 1,500 franchisees in 41 states and 18 foreign countries," says Rogozenski. "Our donuts are baked fresh about every eight hours, and on an average day we bake about 2.5 million donuts worldwide."

Bill Rosenberg opened the first Dunkin' Donuts store in Quincy, Mass., in 1950 and began franchising in 1955. Several years ago Dunkin' Donuts purchased the Mr. Donut chain and two years ago the company was acquired by Allied-Lyons PLC of London.

Rogozenski is director of treasury services for the Randolph, Mass.-based company. After graduating from WPI with a degree in mathematical sciences, he spent two years in the Army. He earned his master's degree in operations research and industrial engineering at the University of Massachusetts, then worked for five years as a consultant for the government in the food service industry.

He joined Dunkin' Donuts in 1976, and during the next eight years held various positions in operations, real estate and franchising. In 1984 he assumed the post of director of market planning, where he analyzed all proposed new locations, developed a sales forecasting model, and created a market-ranking system. Under Rogozenski's direction, more than 75 market studies were completed throughout the U.S. and Canada, and the company expanded its geographic base into the Southeast and the West. In his present post, which he has held since 1990, he is responsible for providing financing to help operators expand the Dunkin' Donuts concept.

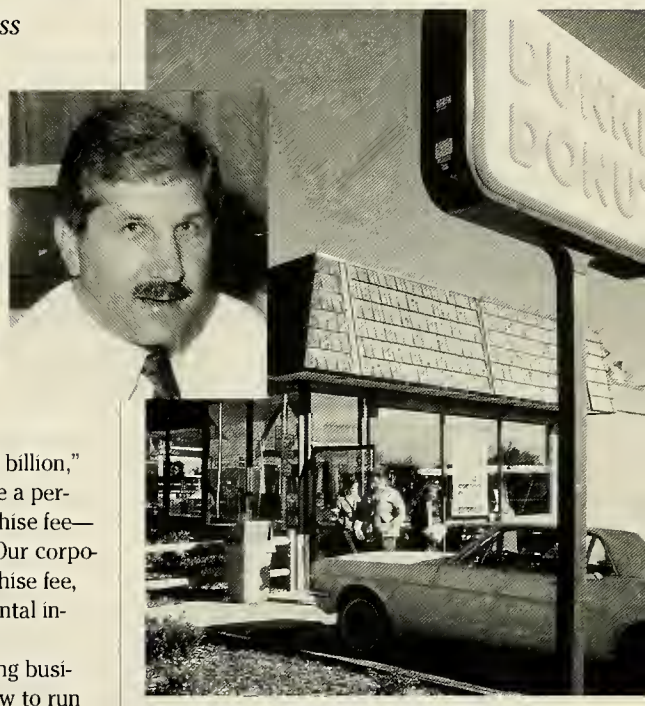
"Our worldwide sales revenues currently are in excess of $1 billion," says Rogozenski. "We typically take a percentage of sales—we call it a franchise fee—that ranges from 3 to 4.9 percent. Our corporate income is driven by this franchise fee, licensing fees for new units, and rental income on property we control.

"We provide the basic underlying business plan and the knowledge of how to run the franchise, the trademark, the patented formulas for the products, and the raw materials. Typically, each franchise agreement is for 20 years, when it must be renewed or transferred. Each agreement is unique to the store's location and serves as the control document we use to standardize the business format. This guarantees that the menu, the decor and the store's image will be the same—whether the customer is in Portland, Maine, or Portland, Ore."

Before opening their stores or assuming an existing franchise, all new franchisees receive six weeks of training at Dunkin' Donuts University in Braintree, Mass. There's a lot to learn. In the past decade the company's product line has expanded from the donuts, coffee and other beverages that were the mainstays of the early shops to include brownies, muffins, cookies, soups and croissant sandwiches.

In the last five years, the company has begun to address the nutritional content of its bakery products—oat-bran muffins made their debut during this period—and the entire donut line has been reformulated so that it is now 100 percent cholesterol free and 90 percent saturated fat free. "The highest selling donut varieties worldwide are, in order: honeydip, chocolate frosted, glazed cake and jelly-filled," says Rogozenski.

"In Chicago and Detroit and on the East Coast our signature item is our coffee—a special, proprietary blend sold by the cup and in one-pound packages with the Dunkin' Donuts label," he adds. "In New England, coffee is king—more than half of our shop sales are derived from coffee. We're really proud of that, because it tells us that consumers recognize and appreciate our high standards. Our commitment to freshness is so high, store employees must discard coffee that is more than 20 minutes old."



Rogozenski, insert, has helped make Dunkin' Donuts a worldwide success.

The company's goal is to continue to grow, particularly in markets it has not previously penetrated. "We are under license to Marriott Corp., which has added full-service Dunkin' Donuts shops to the food courts it operates on the New York Thruway in the Rochester, N.Y., area," says Rogozenski. "We plan to increase our visibility in this type of setting and to place our shops in other such nontraditional locations as airports, colleges and hospitals."

—Bonnie Gelbwasser

Engineering Dining Excellence

As vice president of architecture and engineering, Bryce Norwood is helping General Mills build one of the nation's most successful restaurant enterprises.

Across the country, from California to Connecticut, there are approximately 1,000 restaurants that bear the mark of Bryce A. Norwood '62. First as an engineer for Friendly Ice Cream Corp. in Wilbraham, Mass., and now as a vice president for General Mills Restaurants Inc. in Orlando, Fla., Norwood has led design and engineering teams that have helped create coffee shops and dinner houses from coast to coast.

In fact, with General Mills' two dinner house concepts—Red Lobster (seafood) and The Olive Garden (Italian food)—each growing at the rate of about one new restaurant per week, it's getting difficult for Norwood to travel anywhere in the U.S. or Canada without seeing the products of his efforts.

Norwood says he didn't start out to work in the restaurant business. After he received his degree in civil engineering from WPI, he worked for Johns-Manville Corp. in the company's research center for five years, then joined Keller Products Inc. in New Hampshire, a maker of package structures. While there he heard of a job opening at Friendly, a company he had previously known only from its coffee shop near the WPI campus.

"I'd been impressed by the quality of that restaurant," he notes, "and said, 'if that's what the company's all about, I'd like to give it a try.'" At Friendly, Norwood ultimately became director of design and engineering. In that post he was responsible for planning all new Friendly restaurants.

"We did most of the work ourselves," he says. "When I left, there were nearly 50 people reporting to me and we would draw all our own plans and do all our own engineering. Friendly is a highly vertically integrated company. It acts as a general contractor for all construction and operates its own cabinet shop to make booths and counters. For a while, it even made prefabricated restaurant buildings that we'd lower onto the sites with a crane."

Bryce Norwood keeps restaurants going up at a rapid pace for General Mills.

Norwood says his years at Friendly taught him a great deal about designing and building restaurants. "I learned far more than civil engineering," he says. "I now know mechanical and electrical engineering—at least for restaurants—as well as I do civil. I really like the restaurant business because the challenges are constantly changing. So when I came to General Mills, it was really exciting, because while Friendly is a regional chain, General Mills is nationwide and into Canada, as far as my responsibilities go." [The company is also part of a joint venture that builds restaurants in Japan.]

Norwood joined General Mills Restaurants in 1986 as director of design. In 1987 he was named vice president of architecture and engineering. The company operates more than 800 Red Lobster and The Olive Garden restaurants in North America.

"The Olive Garden concept was developed over the course of six years," Norwood says. "When I joined the company, there were about 10 of them and three or four under construction. Today, there are more than 270 The Olive Gardens, 250 of them constructed in the last five years. That's almost one per week since the chain began. The Olive Garden was what brought me to General Mills. I thought it was a wonderful concept that could go anywhere in the country, and so far it has."

Above, the exterior of a typical Red Lobster. Below, top, the dining areas of The Olive Garden restaurants are geared to the customer. Below, bottom, a new The Olive Garden opens in Texas.

Norwood says the distinguishing qualities of Red Lobster and The Olive Garden—fresh and well-prepared food, comfortable and attractive surroundings, and friendly, attentive service—have made General Mills Restaurants the nation's largest and most successful dinner house operator. (A dinner house is a full-service, sit-down restaurant with a varied menu; often, dinner houses serve alcoholic beverages and have separate lounges.) Today there are more than 500 Red Lobsters, making it the largest seafood restaurant operator in the world. The Olive Garden also holds the top spot in its category.

Norwood heads a team of 25 engineers, architects and designers who are busy keeping track of more than 50 restaurants currently under construction, and dozens of others at various stages of the design and planning process. Unlike Friendly, General Mills Restaurants hires outside architects and engineers to do the detailed plans and contract documents for its restaurants, while Norwood's team completes the space planning for the units, designs the food service areas, and supervises the entire design and permitting operation.

Norwood says General Mills prefers to design its buildings using prototype elements for both Red Lobster and The Olive Garden concepts, although sometimes site conditions or local restrictions call for modifications. "A lot of times the folks building a shopping center that we will become part of want us to match their architecture," he says. "Sometimes we have to stretch our building out or shrink it to fit a site. So, we design a lot of custom buildings."

General Mills also buys existing restaurants, if they are on desirable real estate, and converts them to Red Lobsters and The Olive Gardens. "This is the fastest way to go because the site work is already done. Plus, you don't have to worry about the weather, because you're working indoors." Building a typical new, 9,000-square-foot restaurant takes five months, Norwood says; a conversion takes as little as three.

Norwood says the process of creating a new restaurant begins when the company finds the optimum site in a market and purchases it. Then the project comes to Norwood's office. There a site-development team begins the site-planning work and gathers information on local permitting requirements. Another team hires architects, civil, electrical and mechanical engineers, and a landscape architect, and begins developing the plans. When the plans are complete and the permits are in hand, the project is turned over to the construction division.

During the current fiscal year, which will end in May 1992, about 120 new restaurants will have been completed, Norwood says. To maintain that pace, he notes that his division is currently beginning work on a new unit every two business days. "The pace is hectic," he says. "But we've got a great team of people here, and we just crank the units out."

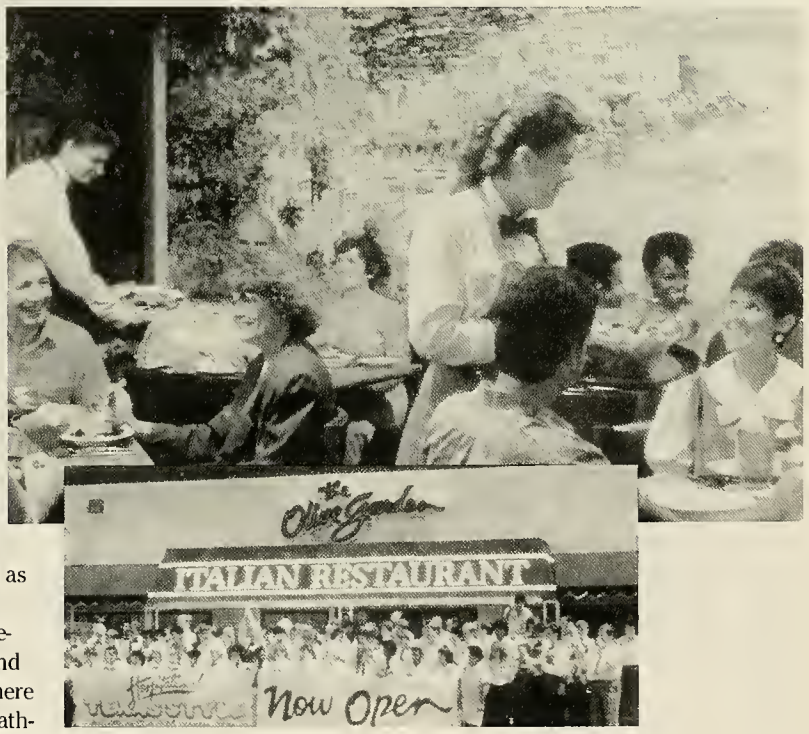
While new restaurants occupy most of Norwood's time, he is also undertaking a project to completely refurbish and redecorate every Red Lobster. "We did 51 restaurants last year, when we kicked the program off, and we'll do 125 this year," he says. "Basically it involves updating the booths, tables, chairs and carpeting. We often put up a new ceiling, wall treatments and walls. The process takes approximately two-weeks, since we do all the work at night so we don't have to close the restaurants."

The new decor—which includes dark wood wainscoting, plum and navy carpeting, the extensive use of live plants, and hand-painted signs and wood carvings with a nautical theme—is indicative of General Mills' commitment to giving customers what they want. "The interiors of our restaurants are very much attuned to the customer," he says. "They offer privacy, comfortable and attractive surroundings, a quality chair and table to sit at, and so on."

While the "front of the house" is geared to comfort, the back is designed for efficiency. "The kitchen is built to optimize the flow of the product from its arrival at the restaurant, to its preparation and cooking, to its being served to the customer. After all, an extra step taken repeatedly over an eight-hour shift can really wear you out. That's why we have five food service designers working for us."

While his work keeps him quite busy, Norwood says it's always rewarding. "It's an exciting job," he says, "and it's given me a great deal of satisfaction to see both of our restaurant concepts grow as fast as they have."

—Michael Dorsey



Harnessing the Waves

Under the direction of the father-and-son team of Gordon and Glenn Walters, A.D.Tech is making a science of microwave cooking.

JANET WOODCOCK

Glenn Walters, left, and his father Gordon with some of the products that use the metallized films and field modifiers made by A.D. Tech.

If you like the convenience of microwave cooking, but hate cracking your incisors on unpopped popcorn kernels or biting into the soggy center of a microwave pizza, Glenn Walters '76, president and founder of Advanced Dielectric Technologies Inc. in Taunton, Mass., is coming to your rescue—in a big way.

His A.D. Tech is the undisputed technical leader in the manufacture of metallized films (known as susceptors) and field modifiers used to improve the performance of microwave food cooking packages. In addition to the standard susceptor films used in microwave popcorn pouches and similar applications, the firm has introduced four new metallized film products under the trade names of Accu-Crisp 1000 and 2000, Accu-Wave and Barrier-Wave.

"These new films are providing major food companies with improved safety, better-quality microwave cooking, and dramatic reductions in the uneven cooking now created by microwave ovens," says Walters, who earned his bachelor's degree in mechanical engineering at WPI.

Typically, the distribution of energy in microwave ovens is spotty, especially when neither a turntable nor a mode stirrer are used, Walters explains. Another problem is that the center of any frozen food product is exposed to less microwave energy than the edges. For example, standard microwave pizzas come out of the oven with cold centers and unevenly crisped crusts.

"Our Accu-Crisp 2000 double-metallized susceptor film modifies the electromagnetic field produced by a microwave oven in a manner that eliminates cold centers," reports Walters. This technical breakthrough was accomplished by using proprietary patterns of metallized films that focus more of the microwave field toward the center of the food product.

The company's Accu-Wave metallized films, similar to Accu-Crisp 2000, are used where browning and crisping are not required, for example in a three-compartment food product where the main entrée, such as beef or turkey, must be heated to a higher temperature than the adjacent dessert. Placing Accu-Wave film over the entree causes the energy to be focused where it is needed most.

The unique "phased array" pattern in Barrier-Wave films keeps oxygen and moisture from reaching the contents of a food package, but allows microwave energy to pass through to cook the food. Traditional metallized bags or foil lidding stock for food trays arc and self-destruct when placed in a microwave oven. Barrier-Wave overcomes the arcing problem.

"This new metallized patterned film is being tested not only for snack food packages and lidding stock for food containers, but also as a replacement for foil now found in asceptic packages, such as boxes for soups and hot chocolate," says Walters.

Due to environmental concerns, foil-film aseptic packages, which can't be recycled, have already been outlawed in Maine. With the use of A.D. Tech's Barrier-Wave products, foil can be eliminated. The food is heated as usual and the packages are readily recycled.

These new products, along with the metallized film capacitors that A.D. Tech also makes, have high quality-control require-

ments. Over the past two years the company has installed computer data-acquisition systems for monitoring and archiving critical quality parameters.

Glenn Walters' brother Mark, a 1984 WPI graduate in electrical engineering and the founder of CIMTECH (Computer Integrated Manufacturing Technology) in Taunton, has been instrumental in assisting A.D. Tech in its efforts to attain zero defects. His services have been facilitated by A.D. Tech's quality control manager, Walter Drew '90, who also holds an electrical engineering degree.

Although it is currently expanding its lead in the food film packaging market, Advanced Dielectric set out in a different direction when it was founded by Glenn Walters in 1983. Initially the firm manufactured engineered metallized polymer films, with most of its product sales in the field of metallized film capacitors.

In 1985 Glenn was joined by his father, Gordon Walters, a 1955 mechanical engineering graduate of WPI, who took the key position of chief executive officer and currently handles all marketing and technical sales for metallized capacitor films.

"Even though we are now the third largest producer of these specialized films in the U.S., by 1989 it became apparent that the company needed a new product area for future growth," says Walters. "We hired Paul Knollmeyer '76 as new product development manager."

After a year of research into alternative markets for vacuum-deposited films, such as flexible circuits, solar films, electrostatic discharge protection films, and holograms, the company entered the burgeoning new field of susceptor films for microwave food applications.

At first the spiraling growth in the market for these films was primarily fueled by the tremendous success of microwave popcorn, which requires a precise susceptor to generate temperatures as high as 400 to 500 degrees Farenheit in the microwave oven. Since typical heating temperatures in microwaves are only in the range of 200 to 250 degrees, these new susceptor films offered food companies a way to dramatically improve microwave heating and cooking.

Today, according to industry estimates, microwave popcorn unit sales exceed 2.5 billion per year and continue to grow.

A.D. Tech began selling susceptor films nearly two years ago and continues to increase its market share.

A.D. Tech entered this new food product area because Glenn Walters says he believed the firm's electronics background would give it a technical edge in introducing new and improved microwave packaging films. Since then the company has become the technical leader in the field.

John Buckley '61, the company's chief financial officer, has also assisted in the growth of A.D. Tech. He has been instrumental in financial planning, including the recent task of licensing and joint venturing A.D. Tech's microwave technology to food- and packaging-related companies.

With more than 80 percent of U.S. households owning at least one microwave oven, the potential for additional explosive growth for metallized film products is overwhelming. Says Walters, "Managing the growth and demand for products that improve microwave cooking performance while not diluting our service and sales to the electronic capacitor market, is an ongoing challenge requiring 100 percent of our attention."

—Ruth Trask

JANET WOODCOCK

A.D. Tech CEO Gordon Walters, front row, center, with sons Glenn, front row, right, A.D. Tech's founder, and Mark, front row, left. In the back row are fellow WPI alumni and A.D. Tech employees John Buckley, left, and Walter Drew.

The Kitchen Magician

For Robert Cassanelli, Creating New Food Products is as Easy as 1-2-3.

Believe it or not, you may be beholden to Robert Cassanelli '62 for the compliments you received for that tasty holiday dessert. The principal specialist at Kraft General Foods in Tarrytown, N.Y., Cassanelli has a long track record as a prime developer of innovative new dessert products, including new flavors and improvements in Jell-O Instant Pudding and Jell-O Pumpkin Pie.

Other products that carry the Cassanelli stamp include Jell-O Fruit and Cream Bars, Jell-O Fruit Bars and Jell-O Gelatin Pops, not to mention Good Seasons Salad Dressing.

Cassanelli, who joined General Foods in 1964, has a B.S. in chemistry from WPI and an M.S. in food science from the University of Massachusetts. He started the climb up the corporate ladder with his successful inauguration of Jell-O 1-2-3 in 1969.

"At the time I was working in the company research labs in Tarrytown, N.Y.," he remembers. "We were whipping gelatin dessert with emulsified vegetable oil and suddenly got a product that developed its own topping."

Wondering what to do with their discovery, Cassanelli and his group prepared samples of the pudding in his favorite flavor, strawberry, and showed it to the General Foods marketing group. A decision was made to start a development project and introduce the product into test markets. Tests were conducted in which consumers were asked to prepare the gelatin, serve it to their families and answer questions about their reactions. "They told us we didn't have enough topping," says Cassanelli. "They all wanted more."

After changing the formula, the new layered dessert was resubmitted to consumers, resulting in excellent reviews; it was subsequently put on the market as Jell-O 1-2-3. Marketed in cherry, raspberry, orange and lime flavors, as well as the original strawberry, it found its way to supermarket shelves from coast to coast and into millions of American kitchens.

In 1970, 1-2-3 hit the big time as one of seven products selected from a field of 54 new food items to receive *Canner/Packer* magazine's annual New Foods Awards. The judges called 1-2-3 "a tremendous innovation. A very unique approach to a simple everyday dessert." They were impressed that it formed three distinct layers when whipped—a gelatin on the bottom, a chiffon-like middle, and a creamy topping. "Not bad for what started out as something of a laboratory curiosity," Cassanelli says.

Cassanelli with some of his creations.

Interestingly, Jell-O 1-2-3 was reintroduced nationally in 1989 under Cassanelli's supervision and won consumer approval once again. A successful reintroduction such as this is rare, and 1-2-3 is one of only a few products to achieve the distinction.

In 1974, Cassanelli, his wife, Terry, and their children, Craig, Cheryl and Carrie, transferred to Dover, Del., where he worked on products sold under the Jell-O, Good Seasons and Baker's trademarks. Among the projects he was involved with was the development of pistachio instant pudding. During that time he took several trips to California to evaluate and select pistachio nuts for the pudding. "I ate so many pistachio nuts I never wanted to see one again," Cassanelli says.

In 1981 the Cassanellis moved to Cranbury, N.J., where Bob worked at the General Foods Technical Center. For several years he helped develop and launch the manufacture of frozen novelties at plants in upstate New York and Indiana. The project required that he take several trips to the West Coast to find strawberries and other fruit for the products.

Cassanelli, who is co-author of five patents, including the one currently covering Jell-O Instant Pudding, says that while studying chemistry at WPI he yearned to move into a field that had practical applications. One day he started reading about microbiology, food chemistry and food processing, and says, "I found the field fascinating."

Named principal specialist at Kraft General Foods in 1989, Cassanelli continues to be enthusiastic about his career. "The opportunity to develop new and innovative food products is still present," he says, "awaiting someone to take an idea and create a product that meets a consumer need. It's been a wonderfully challenging and rewarding career and I now enjoy coaching the new generation of food scientists as they begin their careers."

—Ruth Trask

Spurring Private Enterprise in Hungary

Interactive Qualifying Project by David R. Cote '92, Ajay Khanna '92, and George M. Regnery '92.

Advisor: Leon S. Graubard, associate professor of management.

Hungary is considered the most economically advanced country in Eastern Europe. Between 1989 and 1990 joint ventures between Western and Hungarian companies increased about tenfold—from 770 to 7,000—a reflection of a warm economic climate now divested of its communist cloak.

Cote, Khanna and Regnery used Hungary as an example of the improving prospects for international business involvement in Eastern Europe. They also compiled a reference manual for use by potential investors, multinationals evaluating their prospects there, and students.

The students conducted telephone and fax interviews with a number of Hungarian officials and with representatives of Price Waterhouse and Digital Equipment Corp., both of which have offices in Hungary. They compiled a large database from these sources, from articles and reprints, and from flyers distributed by the Hungarian government. (The database is available to anyone interested in finding out more about investing in Eastern Europe.)

In the 1980s, major economic reforms were implemented in Hungary (which had a capitalist economy before World War II), particularly in the area of banking, even though there were no clear signs that the country would become independent of the Soviet Union. More recently, Parliament has been actively involved in revising laws to make the business climate more attractive to private and foreign investors.

Hungary's foreign debt is currently in excess of $20 billion; two-thirds of that debt is from Western commercial institutions. The country has received aid from international organizations, including the World Bank, the International Monetary Fund, the European Community and several Western countries.

The students say that while doing business in Hungary will be more difficult than doing business in a Western nation with a developed economy, the potential for high profits exists. "Hungary's people are motivated and ready for Westernization, and its economic infrastructure meets the needs of private businesses," they report. "As one entrepreneur said, 'Hungary is like the old West. If you're willing to get your hands dirty, you can't lose.' "

MICHAEL OORSEY

Khanna, left, and Cote say Hungary is eager for economic ties with Western nations.

Improving Care for Diabetics

Interactive Qualifying Project by Paul N. Cedrone '92, Laura A. Gregory '93, Mark A. Nelson '92, Kenneth V. Packard '93 and Cynthia Richards '93.

Advisor: Domokos Vermes, associate professor of mathematical sciences.

Sponsor: Veterans Administration Medical Center, Seattle, Wash.

Fourteen million Americans have diabetes. Through early diagnosis and careful monitoring of blood sugar levels, diabetics can improve the quality of their lives and prevent painful and expensive complications. But many diabetics find it difficult to monitor their blood sugar levels without guidance from physicians or other health care professionals.

Cedrone, Gregory, Nelson, Packard and Richards were invited by the Seattle VA Medical Center to conduct a study of the strengths and weaknesses of the center's current system of educating and caring for its diabetic patients. The students' efforts were part of a federally supported study by Vermes and some of the hospital's doctors aimed at improving the quality of outpatient care by making optimal use of existing resources.

The students interviewed 74 patients and many members of the hospital administration and staff. They also attended clinic sessions and patient education classes to gain direct insight into the interactive communication process between patient and provider.

They demonstrated that, even in a successful, top-quality health care delivery system, hidden resources can exist. By reallocating these resources, the hospital can improve the monitoring skills of its patients and the general quality of care—yielding better health and an improved quality of life for these diabetic veterans.

Their recommendations included

- Increasing the number of personalized clinic sessions run by nurse practitioners;
- Freeing nurses for other responsibilities by relying on programs of the American Diabetes Association and select community resources;
- Tailoring existing diabetes education classes more closely to the comprehension levels of typical VA patients;
- And reducing travel and other costs by decentralizing care through agreements with non-VA providers in distant rural areas.

Vermes says that while the diabetic veterans of Western Washington State will be the primary beneficiaries of the study, similarly structured surveys could help cut costs and improve quality and patient satisfaction in other fixed-budget health care systems.

—Bonnie Gelbwasser

The Decline and Fall Of Science in the U.S.S.R.

By Paul and Sharon Davis

While the majority of Soviet citizens hail the end of communism and the failure of the recent coup, Russian scientists look to the future with uncertainty and doubt.

Dusk envelopes the towers of Moscow State University.

In the early evening, standing on one of Moscow's Lenin Hills, with the university's squat, Stalinesque tower behind him, a Western mathematician can look out over the city's sparkling lights and see symbolic glimmers of hope. Democracy and economic reform are spreading through Eastern Europe. In this city, only a short time age, Muscovites combined ancient courage and modern communications to stop a military coup.

But Russian mathematicians, eyes cleared by bitter experience and Eastern fatalism, might see in those same lights warning beacons of coming professional and personal hardships. Conversations with many Eastern mathematicians, and recent visits with others in Moscow and St. Petersburg, suggest that their fears are neither isolated nor misplaced. And, the fate of the other sciences will certainly be similar.

These scientists have hardly been isolated from political events. They point proudly to hand-lettered signs in the streets remembering those who died to stop the coup. Others tell of triumphs of technology, of messages sent by fax and electronic mail to the West even as the coup leaders cracked down on other forms of communication. But instability, regardless of the ultimate outcome, threatens the practice of science in a culture with deep and productive roots.

Mathematics, like all fields of science, requires a particular ambience for its successful pursuit: a good library, a quiet place to work, perhaps computing facilities, and most of all, talented students and colleagues. Communication through journal publications and participation in conferences is also important. Except for some shortages of computing equipment, Russian mathematicians in the larger cities have enjoyed these benefits for many years. Indeed, the productivity of their educational and scientific systems is world renowned.

Unlike socialism, science can reward its best workers with the pleasures of intellectual achievement and peer recognition. Those rewards can translate into higher positions, better access to such professional necessities as students and travel to meetings, and in the privilege-driven Soviet system, access to better apartments, cars and the other accoutrements of Western civilization.

The principal vehicles of financial support for leading Soviet mathematicians are universities and research institutes. One's relationship with a university there is much the same as it is in the West: teaching earns salary and its own satisfactions, as well as access to libraries, offices and research students.

The research institutes have few Western models in size, scope or intellectual independence. They range in size from perhaps 150 scientists to more than 1,000. They are often housed in their own buildings, where long, musky corridors connect offices piled with books, papers, tea cups and the other paraphernalia of the life of the mind.

Russians can watch with horrified fascination the wave of economic havoc rolling toward them from Eastern Europe, threatening both universities and research institutes with loss of funds for libraries, students and research staffs. In the former East German universities, for example, a committee of outside faculty, elected university faculty and students is determining which faculty positions will be eliminated and who will fill those that remain. Faculty who once held a position for life must now reapply for that same job, if it survives.

During the year it will take the committee to do its work, faculty members may take advantage of the recently lowered retirement age of 57. Members of departments like Marxist and Leninist studies have already packed their books.

Employment as a scientist in private industry offers little hope, both because of the traditional separation in the old Eastern bloc between the universities and the industrial ministries, and because those industries are in a terminal state. Only a third of the approximately 9,000 former East German industries available to Western buyers have been sold. "And those were the easy ones," one professor

Memorials to the coup's victims sit before the barricaded Russian House of Parliament.

explained. Many of the factories awaiting sale are scheduled to close in the near future, laying an economic death sentence on the heads of their employees.

Although Western faculty members might applaud the coming of democracy to these universities, most Eastern scientists find that the joys of university politics pale in the face of lost jobs and closed departments. Russians have already heard too many sighs from their East German neighbors, who wish that the wall and their jobs were still in place. They tell of the dog commenting on the new open society: "Yes, my leash is one meter longer, but my bowl is at least one meter further away. The only improvement is reaching my master's shoe when I lift my leg."

These economic difficulties are aggravated by the Soviet system of managing science. The 300 members of the U.S.S.R. Academy of Sciences have considerable authority over the operation of the research institutes, unlike their American counterparts in the National Academy of Sciences, whose prestige gives the recommendations of the National Research Council substantial moral weight, but little financial authority. Copyright, publication in the West, and most scientific publication within the U.S.S.R. have been controlled, until recently, through the Academy of Sciences and such organizations as the central copyright agency, V.A.A.P., and the state scientific publishing house, Nauka.

Federal research support in the U.S. is diffused by congressional appropriation through a variety of agencies and laboratories, including the National Science Foundation, a number of Department of Defense agencies and many others. Publication is likewise spread over an array of nonprofit professional societies and commercial publishers.

U.S. scientific research is also supported directly through major industrial laboratories and industrial support of university research, and by universities supporting research with their own funds. For better or worse, much of that research is focused on particular outcomes, such as controlling electric power networks or predicting the spread of AIDS.

In contrast, the Soviet system of narrowly defined academic departments and research institutes promotes Balkanization, even among subspecialties of the same discipline. The average Soviet scientist is well removed from direct involvement with industrial or defense problems. The work of the industrial ministries is separated bureaucratically from research at universities and institutes. Even at the most fundamental levels, defense work is cloaked in secrecy.

Soviet applied mathematicians, for example, see grandiose problems like models for laser heating of an ideal material, but they seldom work with actual technological implementations like the design and manufacture of laser distance-measuring interferometers.

Rather than a fine web of research funding, Russian scientists depend upon a few large supporting cables. If those are cut, their research establishment will surely crumble. The immediate loss may be a generation of scientists—those presently holding or seeking junior positions. Doors will close to them as senior positions are eliminated. When the situation finally brightens, those once-young scientists will be too old or too lacking in accomplishments to move up the ladder.

A longer-term loss may be the "feed stock" of science. Just as Muscovites joke that the queue has moved from Lenin's tomb to McDonald's, the queue of young people in the educational system may move from science, with its poor rewards and uncertain prospects, to the newly found pleasures of the business world.

The situation is even bleaker in the other Soviet republics. While each republic typically has its own academy of science, and several of its most distinguished scientists are members of the dominant U.S.S.R. Academy of Sciences, their support by the central government has been weaker than the major research institutes in the large Russian cities. Computing equipment and software is a particular difficulty; at most universities one finds a few old PCs and some bootleg software.

Since the economic fate of these smaller states was tied directly to Russia's, they have suffered badly as precious hard currency has been diverted to pay for necessities like oil that were once traded easily in the U.S.S.R.'s closed economy. For example, electricity was cut off regularly last winter in parts of Sofia as a conservation measure, in spite of the cold and darkness. One mathematician working in Sofia leaves his daughter with his parents in the country, where they are less dependent upon unreliable city services.

Economic hardship extends far beyond science, of course, and its damage is easily understood. More difficult to appreciate are the subtle cultural changes that accompany the collapse of central authority, particularly the Communist Party.

A blessed benefit of that collapse is the end of state-sanctioned anti-Semitism. One

The statue of KGB founder Felix Dzherzhinsky lies in a Moscow cemetery.

"Finally...They See a Future"

Alvin H. Weiss

From late August to early October, while students back at WPI were opening their books once again after the summer recess, Alvin H. Weiss, professor of chemical engineering, was busy opening doors in the Soviet Union and Bulgaria.

Weiss spent two weeks on a National Research Council Fellowship in Moscow and Krasnayorsk in the U.S.S.R. establishing research collaborations at the Institutes of Chemical Physics, Organic Chemistry and Organic Raw Materials. He then visited the Institute of Kinetics and Catalysis in Sofia, Bulgaria, under the auspices of the National Science Foundation, setting the stage for research collaborations there.

Weiss also presented papers and lectures on his own research in catalysis and petrochemicals, and chaired special sessions at conferences in Krasnayorsk and Bourgas, Bulgaria. The meeting in Krasnayorsk was the first international conference held in the city, which claims to have the world's largest hydroelectric station and aluminum plant, and is also home to extensive petrochemical, refining, rocket and mining industries. Once an "island" in the infamous Gulag archipelago, the city was formerly closed to foreign visitors.

Weiss says his visit gave him ample opportunity to find out how Soviet citizens are faring in the wake of this summer's failed coup attempt. "Attitudes were very upbeat," he says. "Finally, they see a way out, a future."

He notes that the bleak financial situation in the Soviet Union has cut off funds for scientific trips and supplies, though he says the chemical engineering institutes he visited have received much needed small instruments, including personal computers, during the past year and a half.

"Some small institutes will be closed and those in Moscow are experiencing personnel cutbacks," he says. "The general consensus is that the Soviet Academy of Sciences will become merely an administrative presidium, and that the institutes will have to generate their own financial support. Even now, about 50 percent of their efforts are supported by industrial contracts."

Weiss, who joined the WPI faculty in 1966, has become widely known for his work to forge research collaborations and share his expertise with scientists around the world, especially in developing nations. With Fulbright grants and support from the U.S. State Department, NASA, the National Science Foundation and the United Nations, he has worked with researchers in Argentina, Brazil, China, Hungary, Israel, Turkey, and Vietnam, in addition to the Soviet Union and Bulgaria. In 1985 he became the first U.S. chemical engineer to be invited to lecture in Vietnam since the end of the war in that nation.

—Michael Dorsey

mathematician, showing me his latest book, pointed to a co-author's name and said in hushed, apparently embarrassed, tones, "He is emigrating to Jerusalem next week." Only later did I learn that he, too, was a Jew who had been forbidden to travel until only a few years ago. His hushed voice was a lament for the difficult times his friend would face in relocating his family and resuming his professional life when there was now some hope in Russia.

The structure and life of science in the Soviet Union has been intimately tied to the Communist Party. With its collapse, and with the possible vilification of many of its former members, has come complete upheaval in routine functions. Travel funds within research institutes, for example, are allocated by a committee of senior scientists. Orthodox behavior was presumably a prerequisite for membership on the committee and for successful processing of a travel request, especially for foreign travel. Otherwise, in the words of a mathematician, "One faced infinite complications."

Scientists who are affiliated with the Communist Party for career-advancement reasons face the greatest danger. Uncertain about the party's future, they must now maintain a low profile and worry that retributions against the party will not adversely affect their scientific careers. Like Soviet President Mikhail Gorbachev, they are learning that it is not possible to sit on two chairs at the same time.

Symbolically, perhaps, the new high-rise central office building of the U.S.S.R. Academy of Sciences sits half empty. Some argue that the money used to erect the "golden brains building," named for the stylish bronze panels that shield its upper floors, would have been better spent in support of research. Others simply prefer the familiar surroundings of the Academy's older Praesidium.

Indeed, the role of the U.S.S.R. Academy dwindles as the old union collapses. Since Russia, unlike the other republics, has no academy of sciences of its own, the U.S.S.R. Academy might fill that role. Soviet President Boris Yeltsin has already appointed an organizing president for the new Russian Academy. Elections later this fall will determine the entwined fates of the old Soviet Academy and the new Russian institution.

Apropos the uncertainty in the lines of authority, I asked a colleague about the fate of the Leninist murals that decorate the ceiling of the Moscow train station in St. Petersburg. Sardonically he answered, "Perhaps they will just replace Lenin's face with Christ's."

At all levels, the security and certainty implicit in an academic career have been taken from senior personnel, who accept the change with quiet resignation. They continue to work vigorously and to hope for opportunities for their children. Younger scientists are more restless. All turn toward the West.

Driving away from the Kremlin across the Moscow river and along the Lenin Prospect, one passes the defaced granite bases of statues of Stalin, Marx and Lenin, their formidable visages now laid out among the tombstones in a distant Moscow graveyard. But at Gargarin Square, barely two kilometers from Lenin's tomb, the statue of that beloved cosmonaut stands securely on his own obelisk, a symbol of socialist patriotism and simple human courage. Although Westerners find hope in the evident courage of our friends, our more sanguine Russian colleagues fall back on a proverb: "We will live. We will see."

Paul Davis, the current John Sinclair Professor of Mathematics at WPI, and Sharon Davis, director of alumni programs, recently returned from a one-week visit to the Soviet Union, where Paul, representing the Society for Industrial and Applied Mathematics, visited a number of mathematicians in Moscow and St. Petersburg to discuss possibilities for cooperative activities.

Clockwise from right, the authors in Red Square with a Russian translator and guide, at left; a former convent that served as Communist Party headquarters in St. Petersburg—the authors found it deserted during their visit; the new Soviet National Academy of Sciences headquarters, known among Soviet scientists as the "golden brains" building.